Queensland.

DEPARTMENT OF MINES.

GEOLOGICAL SURVEY REPORT,
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WOLFRAM AND MOLYBDENITE MINING IN QUEENSLAND.

BY

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WOLFRAM AND MOLYBDENITE MINING IN QUEENSLAND.

I.—HISTORICAL AND STATISTICAL.

Mining for the minerals wolfram and molybdenite has of late years assumed some degree of importance in Queensland, on account of their having recently come into more extended use in the arts, and from their occurring in considerable abundance in several localities in the northern part of the State.

Wolfram was first found in payable quantities in 1894 on the Hodgkinson Gold Field, at a place now known as Wolfram Camp. Sixty-five tons were sold during the year, and realised about £650. Subsequently the mineral has also been mined in some quantity at Lappa, near Petford Siding, on the Chillagoe Railway Line, on the same goldfield. Other small parcels have been obtained at Tinaroo, near Mareeba, at Coolgarra, on the Herberton Tin Field, at Port Douglas, the Kangaroo Hills mineral field, and at Noble Island, 100 miles north of Cooktown. The mines at Wolfram Camp and Lappa have, however, furnished the great bulk of the Queensland supply, and are still being worked. Their record up to the end of 1903 has been 860 tons, of a value on the field of £28,578. The average value of the cre on the field up to the present time thus works out to about £33 4s. per ton.

At Wolfram Camp and Lappa the mineral was found scattered over the ground in waterworn pebbles and boulders, and in smaller grains in the sand of the water-courses and creeks. For the first few years the production was very small. In 1895, 21 tons were sold for £462, but for 1896 there is no return recorded. In 1897, 13 tons brought £195, and in 1898, 68 tons brought £2,040, an average of £30 per ton. In 1899, when the price of the mineral was at its highest, 240 tons were obtained, and realised on the field £9,120, or an average of £38 per ton. Owing to the exhaustion of the more readily obtained surface stone, and the necessity for mining for most of the ore in order to maintain the supply, the production during the next year fell to 188 tons, of an average value of £35 per ton. A heavy fall in the value of the mineral at the end of this year led to a great reduction of the output for the next two years, many of the miners turning their attention more particularly to molybdenite, which had then lately come into good demand. The prices obtained during these two years averaged about £18 per ton, at which figure the mining of the mineral as it occurs in most of the lodes on the Hodgkinson, leaves little margin for profit.

During the early part of 1903, the price increased again rapidly, till it stood at about £30 per ton for clean ore on the field at the end of June. This fact, coupled with the break-up of the drought and consequent amelioration of the conditions of living on the field, led to a revival of mining, the lodes at Lappa now also receiving considerable attention. By September the price had risen to £45 per ton, and the number of miners employed in working wolfram had increased to 150. The return for the year was 138 tons, of a value of £7,251, an average of £52 per ton. By the end of the year the miners were receiving £56 per ton at Wolfram Camp, and £58 per ton at Lappa. Such

prices make the mining of wolfram on the Hodgkinson lodes a highly profitable industry, and if maintained for any time, bid fair to make these localities very important mining centres.

The mineral molybdenite had been found associated with wolfram in increasingly large quantities in the lodes at Wolfram Camp, as these were sunk on below the surface. No market, however, could be found for the mineral till the year 1900, when a visit from a representative of an English ore-buying firm led to the first sale, the mineral having only a short time previously come into good demand. In 1900 the field produced 11 tons of clean mineral, for which £51 was received. The value of the ore rose rapidly, till, at the end of 1902, it fetched £200 a ton on the field. The output increased to 26 tons in 1901, and 38 tons in 1902. Most of this ore came from a few lodes within a circumscribed area at Jeff's Camp, Wolfram Camp, but other lodes also gave small quantities. During the early part of 1903, the price suddenly fell to £120 per ton, and remained at about that price during the greater part of the year. The output for the year was about 10 tons, for which £1,321 was received, giving an average value of about £132 per ton.

Mr. Ball reports the occurrence of molybdenite in the Chowey reefs, Degilbo; in the reefs of the Perry Scrub, and of Mudloo Valley, Kilkivan district; on the Maxwellton Gold Field; and on Blue Mountain Creek, Stanthorpe. A few hundredweight of ore have been sent away from the last-mentioned place.

The accompanying table, compiled from the annual reports of the Mines Department, gives the amounts and values of wolfram and molybdenite ore produced to the end of 1903 in Queensland:—

AMOUNTS AND VALUE OF WOLFRAM MINED AND SOLD IN QUEENSLAND TO END OF 1903.

Year.	Hodgkinson.		Port Douglas.		Kangaroo Hills.		Herberton.		Ravenswood and Star.		Cooktown.	
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
1894 ...	65	650	40	60	...	...	...	...	...	...	...	...
1895 ...	21	462	4	80	...	...	...	...	...	...	...	...
1896 ...	..	...	...	...	3	60	...	...	...	...	...	...
1897 ...	13	195	...	...	...	...	...	...	...	...	...	...
1898 ...	*68	2,040	10	500	10	500	...	...	...	...	...	...
1899 ...	240	9,120	2	90	...	...	...	...	17	850	...	...
1900 ...	188	6,550	...	...	...	...	0½	35	...	...	1	20
1901 ...	72	1,145	...	...	...	...	...	...	...	...	...	...
1902 ...	55	1,165	...	...	...	...	...	...	...	...	...	...
1903 ...	138	7,251	...	...	...	..	...	...	...	...	...	...
Total ...	860	28,578	56	730	13	560	0½	35	17	850	1	20

* Entered in the Mines Department reports to Herberton.

AMOUNT AND VALUE OF MOLYBDENITE MINED IN QUEENSLAND TO END OF 1903, HODGKINSON GOLD FIELD.

Year.	Tons.	Value.
		£
1900	11	561
1901	26	1,609
1902	38	5,329
1903	11	1,321
Total	85	8,820

II.—TECHNOLOGY.

The demand for wolfram and molybdenite is small and irregular, and is easily over-supplied by an increase of production. The prices accordingly fluctuate greatly as the supply falls short of or overtakes the demand. It is consequently impossible to get quotations of prices in the home markets except for *bonâ fide* offers on the spot. The purchasing of these ores, therefore, on the Queensland fields, and the shipping of them to England for sale, is somewhat of a speculative business, the prices being liable to fall or rise considerably before the market can be reached. The increased demand of late years has sprung from the employment of both minerals in the manufacture of special classes of steel, each mineral imparting its own particular property to that metal.

Wolfram.—The useful ingredient in wolfram is the metal tungsten, generally estimated as tungstic acid (the mineral being a tungstate of iron and manganese). The pure mineral contains from 73 to 76 per cent. of tungstic acid. The commercial ore, owing to admixture of quartz, which cannot all be easily separated by hand dressing, rarely contains over 70 per cent., but should not contain less than 60 per cent. The price of the ore is based on the ruling rate for 60 per cent. ore, plus an additional sum for every unit of tungstic acid above 60.

Tungsten, when added to steel in small proportions, renders it particularly hard, and also self-tempering. Tungsten steel is, therefore, used in the manufacture of certain edged tools, and in the wearing parts of machines. Tungstic acid compounds are also used for rendering colours fast in cotton fabrics, and for making dress materials and curtains uninflammable for theatrical purposes.

According to the "Mineral Industry" for 1902, the production of tungsten metal in the United States during 1902 amounted to 82,000 lb., as compared with 13,000 lb. for 1901; ferro-tungsten, 14,000 lb., as compared with 13,000 lb. in 1901; and tungstic acid and tungsten salts, 3,500 lb., as compared with 3,000 lb. in 1901. The prices varied from 58 cents to 64 cents per pound for tungsten metal, and from 27 cents to 31 cents for ferro-tungsten, the prices being practically the same as for the preceding year. The prices of ore varied from about 2 dollars per unit for 45 to 55 per cent. ore, to 4 dollars and a-half for 55 to 65 per cent. ore.

Wolfram is a dark greyish, or brownish black, mineral, with submetallic lustre, and gives a reddish brown powder. It cleaves readily into plates. It is heavy (specific gravity, between 7 and 8). It resembles magnetite, but can be distinguished by its having only one cleavage, and by the colour of its powder, magnetite having four cleavages and giving a black powder. It is non-magnetic, but is easily fusible before the blowpipe, when it becomes magnetic.

Molybdenite.—Molybdenite is a compound of sulphur with the rare metal, molybdenum, and when pure contains 60 per cent. of the metal. Consumers require an ore containing at least 45 per cent. An alloy of the metal with iron is first made, containing about 50 per cent. of molybdenum. The sulphur is got rid of by roasting the mineral, or treating it with nitric acid, thus leaving the oxide of molybdenum. This is then fused in an electric furnace with carbon, and a carbide of molybdenum formed, which, on fusion with molten iron, gives ferro-molybdenum. This alloy, when added to steel in certain small proportions, gives molybdenum steel. It is also added in still smaller proportions to nickel-steel and chrome-nickel steels. These steels contain from .25 to 4 per cent. of molybdenum, by the addition of which their toughness

and elasticity are greatly increased. They are used chiefly for forgings of all kinds, such as gun and rifle barrels, boiler-plates and shells, also for large crank and propeller shafts, and for armour-plates for war vessels.

The "Mineral Industry" for 1902 says:—"The demand for molybdenum has largely increased within recent years, due to the property possessed by the metal of rendering chrome steel self-hardening. It is claimed that the self-hardening property can be imparted to chrome steel by the addition of one half of the quantity of molybdenum, as compared with tungsten."

During 1903 ferro-molybdenum, containing 50 per cent. molybdenum, was quoted regularly in the United States at 1 dollar 25 cents per pound.

The production during 1902 amounted to 35,000 lb. of molybdenum metal, and 16,000 lb. of ferro-molybdenum, the price for the metal varying from 1 dollar 55 cents to 2 dollars per pound. A great portion of this was made from ores obtained from abroad, as only about 12 tons of ore were produced in the country. The value of ore containing between 50 and 55 per cent. molybdenite was about 300 dollars per ton during 1902.

The mineral molybdenite is also used in small quantities for the manufacture of blue carmine, a colour used for painting on porcelain.

Molybdenite is a lustrous, lead-grey mineral, occurring in large masses or smaller plates. It breaks up readily into innumerable thin flakes, which are very soft and flexible, but not elastic. Molybdenite will leave a grey mark on paper, and, when heated over a flame in an open tube, gives off sulphurous fumes. It resembles graphite, but is paler in colour, and is distinguished by its action on heating in a closed tube.

The use of these minerals in steel-making has gone beyond the experimental stage, and seems to be on a firmly-established basis as a recognised method of improving its quality for special purposes. The demand for the minerals accordingly seems likely to remain constant as long as they can be supplied at a reasonable cost, so that it is not necessary to look about for substitutes. As they are used only in very small percentage, their addition does not add greatly to the expense of manufacturing steel even at present prices, which are highly remunerative to the producer. The demand may thus be expected to increase as the steels in which they are used become better known. Since, however, the minerals are only used in small proportion in these steels, which, again, are only suited to a comparatively few purposes, it does not seem likely that this increase will be sufficiently rapid or sufficiently large to long outrun the supply for some years to come. This is especially true in the case of wolfram, which is much more abundant than molybdenite. There seems every prospect, however, of a continuous demand for both these minerals at prices which will stimulate work on the North Queensland lodes for some time.

III.—GEOLOGY.

On the Hodgkinson Gold Field wolfram and molybdenite frequently occur together in the same lode. The former is, however, much the more abundant mineral, many of the lodes containing only small quantities of the latter. The lodes at Wolfram Camp, in fact, are the only ones in which molybdenite has been found in payable quantities, and there only in a few of the lodes. The gangue is a clean white quartz, often clear and glassy, occupying the joints and contraction fractures of a grey biotite granite. Associated with the wolfram and molybdenite is a considerable quantity of metallic bismuth, which is

also saved and sold. In the lower levels of some of the deeper mines arsenical and iron pyrites are met with. The wolfram and molybdenite occur in large masses scattered through the quartz gangue, the greater portion being easily separated by hand-dressing with a knapping hammer.

In a number of cases the outcrops of quartz occur at intervals along a fairly well defined line, but are of workable size and richness only at detached points. There is never a well-defined and continuous lode with distinct walls of cleavage between the quartz and the granite. In many cases the lode consists of granite veined through with mineral-bearing quartz; in others the quartz occurs in vertical or horizontal veins irregularly distributed through the granite, and seldom continuing of the same thickness for any great distance.

The majority of the rich wolfram-producing claims at the Top Camp, Wolfram Camp, lie along a fairly continuous line of lode. The granite rock here, as shown by the exposures in the numerous shafts and open-cuts, is traversed by numerous contraction cracks, lying roughly parallel to each other and to the surface of the ground. This occurrence gives the granite the appearance of being stratified, and has no doubt been caused by the shrinking of the granite as it cooled and solidified from a molten mass. In many of the claims the quartz of the lodes, on being followed down by vertical shafts for a few feet, has "cut out" on a floor of granite, along which it spread in a horizontal direction. These horizontal veins, on being excavated by mining after the manner in which a horizontal coal seam is mined, are seen to lie parallel to the contraction cracks of the granite, along one of which they have apparently been formed. The horizontal veins do not generally extend to any great distance laterally from the line of lode, being confined as a rule to within a short distance on either side of it. They vary greatly in thickness, and, as the granite is broken across by numerous vertically disposed cross-joints, they are very irregular in their course. The vertically disposed cross-joints also frequently contain seams of quartz and mineral. The thickness of these seams of ore is never much more than 10 or 12 inches. Some of the vertical standing main lodes, however, open out into large bodies 3 and 4 feet in thickness, but do not generally continue at that thickness for more than a few yards.

In a great many cases the quartz of these vertically standing main lodes has apparently been formed along a main joint plane of the granite, and in these cases it is often of considerable thickness, and forms a more or less well-defined lode running for some distance. The smaller, but often much richer, horizontally disposed veins seem to be in most cases off-shoots from these lodes along the main joints. Although they have been found to make into large bodies, and again pinch out into almost nothing within very short distances, these main lodes, with their occurrence of ore at numerous points along a considerable length, encourage the hope that on being followed down they will lead to other deposits at greater depths.

In the more distinctly molybdenite-bearing lodes at Jeff's Camp, the outcrops consisted of "blows," or roughly circular or oval-shaped outcrops of quartz carrying wolfram and bismuth. Molybdenite did not generally make its appearance within the first 10 or 12 feet from the surface. On being followed down by shafts these outcrops developed into irregular pipe-shaped bodies surrounded on all sides by granite, being at times almost vertical and at others dipping flatly. All the quartz was taken out in the circumference of the sinking, granite being left on every side. The quartz graduated rapidly into the granite with no marked plane of division, and both quartz and mineral were often found extending as veins into the granite for some few inches or a foot from the main mass of the quartz.

The jointing of the granite has apparently been the determining factor in the form taken by these lodes, the main joints having allowed of the entrance of siliceous and mineral-bearing solutions from below, which have spread into the surrounding contraction cracks and fissures. The granite walls of the joints have been subjected to considerable alteration at detached points along their length, with a correspondingly great or slight deposition of quartz and mineral. The pipe-like character of many of the lodes is difficult to account for, but may possibly be due to the formation of a more or less vertically disposed conduit for the mineralising solutions along the junction of intersecting joints.

In the majority of the lodes the deposition of the ore has been most abundant along the horizontal contraction cracks, that along the vertical planes merely serving to lead the miner down to more important deposits of the former character below. It seems, therefore, reasonable to suppose that other horizontal seams lying parallel to those above should be found by further sinking, and apparently there is no reason why the depth should be very great, as the contraction planes are closely set together. The deposits are not as a rule of sufficient value to warrant any great outlay in dead work in looking for further deposits, but any sign of quartz going down should be worth following in the hope of striking other deposits of value, occupying lower contraction seams in the granite.

IV.—WOLFRAM CAMP LODES.

Wolfram Camp lies about 14 miles west by north of Dimbulah, a station on the Chillagoe Railway Line, 47 miles from the port of Cairns. A good road from Dimbulah crosses the Walsh immediately north of the railway station, and follows down the right bank for about 9 miles. It then strikes north up the Valley of Four-mile Creek, on which Wolfram Camp lies about 4 miles above its junction with the river.

Jeff's Camp Workings.

These workings lie about half a mile up the creek from the main camp in a tributary gully. A number of claims in this locality are being worked mainly for molybdenite, being all contiguous to one another. The first met with is—

Shaw's Claim.—This claim was worked on the surface for bismuth, and the quartz followed down in a flatly inclined shaft to a vertical depth of 20 feet. A vertical shaft was then sunk to strike the bottom, and the underlie continued on the ore body at the old grade. There is a little quartz showing here and there down the underlie, but practically the whole of it has been removed in the sinking, the greatest diameter of the pipe of ore being less than 6 feet. About 10 feet below the vertical shaft the first molybdenite was struck, and it has continued down another 30 feet to the bottom. The bottom is a mass of white quartz surrounded on all sides by granite, and splashed through with large masses of molybdenite. This was the only mine from which molybdenite was being obtained at the time of my visit.

From six to seven tons of clean molybdenite were obtained from the last 30 feet of the shaft. As the ore brought latterly from £100 to £200 per ton, it will be seen that this has been a very profitable mine, especially as it gave very little trouble in the cleaning of the ore. The molybdenite does not seem to come to the surface in any of these mines, owing, probably, to its weathering easily under atmospheric influences. It generally first makes its appearance at from 20 feet to 30 feet below the surface. The wolfram and metallic

bismuth, on the other hand, are found with little alteration right at the surface, and occur together in the surface soil, where much of the latter is in the form of carbonate.

In dressing the ore the larger lumps of molybdenite are broken off from the attached quartz by hammer, washed, and put aside for bagging. The finer stuff is screened through ½-inch screens, and that remaining on the screen roughly jigged in water. The heavier lumps of molybdenite collect at the bottom of the screen, but the more flaky material, owing to its buoyancy in water, cannot be separated from lighter quartz gangue: and, as there is little sale for anything but clean mineral, a great deal of it is at present wasted. The fines from the first screening are afterwards treated on ⅛-inch and $\frac{1}{16}$-inch screens, and the less flaky portions of the mineral thus saved.

Kenrick's Claim.—This claim lies immediately to the north of Shaw's claim, and adjoins it. The first molybdenite sold from the field was obtained from this claim in 1900. The shaft has been abandoned, as has also a second, sunk on another lode some 60 feet south of it. Both underlay flatly to the north, and were sunk to a vertical depth of about 40 feet. About 12 tons of molybdenite were obtained from the two. A third lode, some 30 feet behind the second, was being worked at the time of my visit. The shaft was sunk first 16 feet vertically on an outcrop of quartz carrying bismuth, which was then followed on the underlie for about 20 feet. The first bunch of molybdenite was struck here, and about 1½ tons obtained in a few feet. The shaft at the time of my visit was full of water to this point. About 5 feet further down, the pipe of quartz turned over vertical, and another patch of ore was followed down for about 10 feet. About 2 tons of clean mineral were obtained from here. The flooding of the shaft during the wet season of January, 1903, prevented further work, and, owing to the inconvenience of bailing, a vertical shaft was being sunk from the surface to strike above the second bunch of ore.

The ore here occurs less in the body of the quartz, and is disseminated more freely through the immediately surrounding granite. This involves greater trouble in obtaining clean mineral for sale, the majority of it having to be broken up fine by a hammer, and repeatedly jigged through screens. This entails considerable expense and waste of the finer portions of the mineral. Mr. Kenrick estimates that it has cost him £30 a ton to clean the ore obtained from this shaft.

There is great need of a cheap and effective machine to save the finer and more flaky portions of this mineral. The specific gravity is about 4.6, as compared with 2.65 for quartz, but the buoyancy of the flakes of molybdenite in water is little, if anything, less than that of quartz of the same diameter. To crush the material by stamps would only accentuate the difficulty. Possibly, if crushed by means of rolls, the quartz would be reduced to a fine state, while the flakes of molybdenite would suffer less comminution than if crushed under stamps, and could consequently be separated from the fine quartz by some form of settling-box. There is not, however, sufficient of this class of ore on the field, nor sufficient demand for the mineral, to warrant the employment of very expensive machinery.

Gillian's Claim.—This claim adjoins Kenrick's claim on the west. A large quantity of wolfram and some bismuth were obtained from a lode striking north and south in open-cut workings, extending for some 2 chains in length and 12 or 14 feet in depth. The lode is seen on the southern end of these workings in about 4 feet of quartz and country rock, the quartz ramifying through the granite in solid veins, and being splashed through with masses of wolfram. The shoot of ore was found to be dipping to the north, and is said

Queensland.

DEPARTMENT OF MINES.

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REPORT.

SOME MANGANESE DEPOSITS

IN THE

GINGIN, DEGILBO, AND WARWICK DISTRICTS.

BY

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SOME MANGANESE DEPOSITS IN THE GINGIN, DEGILBO, AND WARWICK DISTRICTS.

This work was carried out as part of the general scheme of having all the deposits of manganese ore in Queensland inspected and reported on as time permitted. Some of the deposits are acknowledged to be poor, but it is hoped that at some time in the future they may be worked, in order to supply Australian iron furnaces with the necessary manganese ore. The only local demand of any extent at present is that of Mount Morgan, where about a thousand tons a year are consumed in the chlorination process. The management now stipulates that no ore containing less than 70 per cent. available dioxide will be accepted—probably because a sufficient quantity of ore of that grade can be obtained from Mount Miller, near Gladstone. The price paid during 1902 was 1s. 1.3d. per unit, on a basis of 70 per cent., with 1s. 6d. per unit in excess. Ore carrying 70 per cent. available manganese dioxide would thus bring £3 17s. 6d., delivered at Rockhampton.

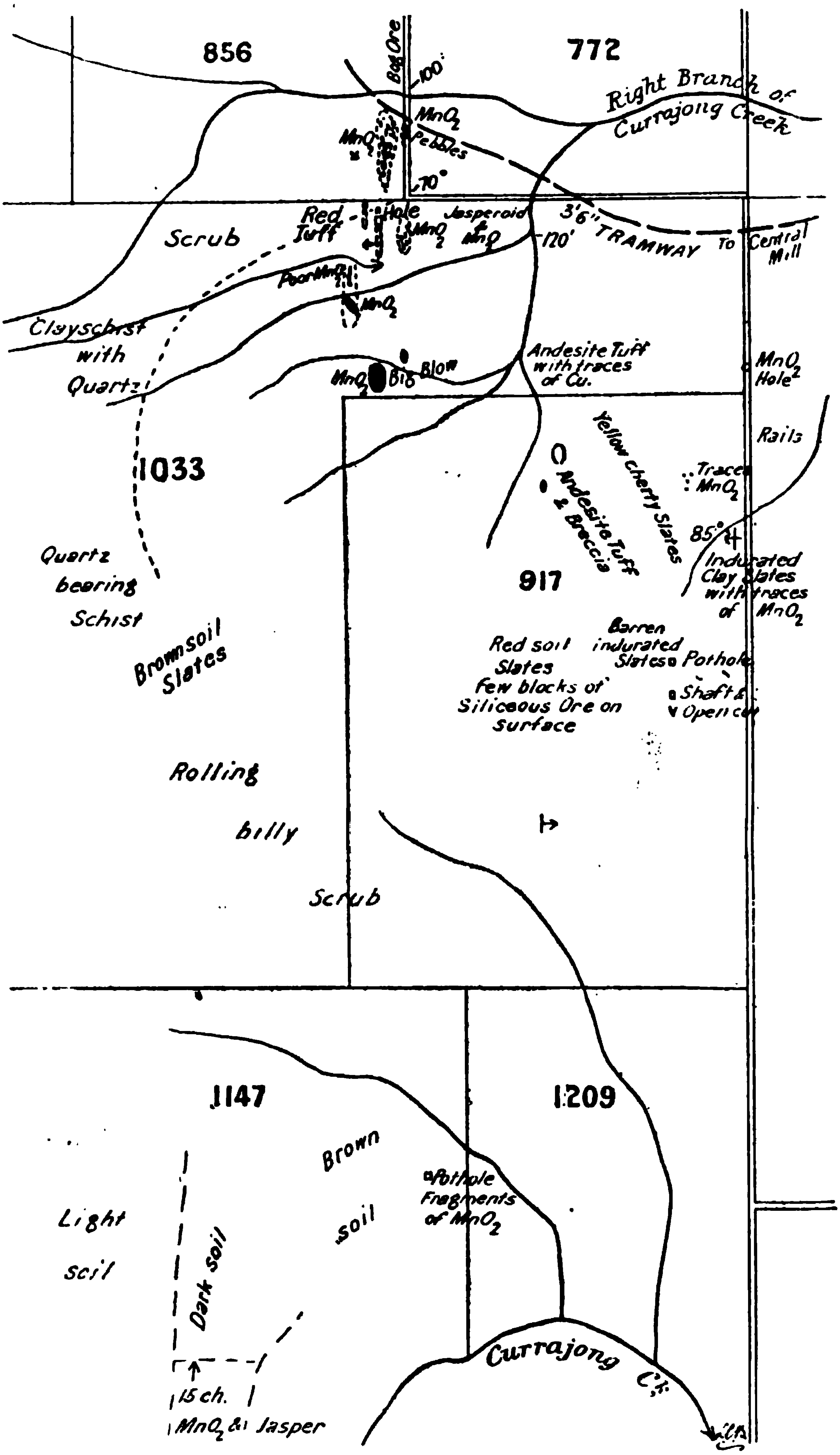
The London quotations for manganese just now (6th November) are:—

Ore containing	50 per cent. and upwards	of	manganese,	9d.	to 9½d.
„	47 to 50	„	„	8d.	„ 9d.
„	40 to 47	„	„	6d.	„ 8d.

i.e., ore containing 44 per cent. of manganese would bring only £1 5s. 8d. per ton. It is evident that only large deposits, most favourably situated, could be made to pay at that price.

GINGIN.

The proved manganiferous country, comprised in an area of 2 square miles, lies 5 miles south-south-west of Gingin Railway Station—the deposits occurring in freehold portions 856, 1033, 917, and 1147, Walla; and Gingin, the centre of a prosperous cane-growing district, is on the Mount Perry Railway, 29 miles from the port of Bundaberg.



SKETCH PLAN OF MANGANESE DEPOSITS IN THE GINGIN DISTRICT.

Scale : 20 chains to an inch.

Good, fairly level roads run to Gingin, and the Central Mill Private Railway connects with Wattawa Railway Siding. Arrangements could probably be made with the proprietors of the private railway for the ore to be carried to the siding, and heavy cartage freights might thus be obviated.

The manganiferous country is gently rolling. It was formerly covered with dense scrub, but most of it is now under cultivation, the slates forming a rich brown soil. It is drained by Currajong Creek and its Right Branch, and a feature of the country is the number of springs, some of which persisted even in the drought.

General Geology.

A narrow north-and-south-stretching zone of slates and tuffs of undetermined age includes all the manganese lodes. In one or two places indistinct and indeterminable fossil remains were found in the tuffs near the lodes. The beds strike north and south, and dip at high angles both east and west, owing to folding, consequent on compression from east and west.

Clay schists with segregated lenticules of quartz occur west of the slates, and similar country—probably a continuation of the same belt—exists in the Perry Scrubs to the south (already described in No. 184 of the G.S.Q. publications, and in *Government Mining Journal* for August, 1903, p. 400). The soil produced is comparatively poor, and the quartz blows carry little or no gold.

Immediately east and north-east of the manganiferous area the slates are capped by rich red and black residual basaltic soils, but they have been denuded a short distance to the east and north-east, leaving sandstones and conglomerates (of Trias-Jura age) exposed.

The tuffs and slates are apparently of much younger age than the schists, but are themselves much older than the sandstones and conglomerates. Nothing is known as to the age of the basalt beyond that it is younger than the sandstone; but, as none of these rocks appear to have any connection with the manganese deposits, their age does not really concern the present inquiry.

Portion 856, Walla.

The area of manganese ore on this portion is in the extreme south-eastern corner, and extends along the eastern side for 10 chains from the southern end. It consists of scattered pebbles and boulders over a width of from 40 yards at the northern end to 2 yards at the southern. At 6 chains from the southern boundary is a solid outcrop 6 feet wide. The wider parts are due to the occurrence of a number of separate lenses, not to a thickening of one single lens.

The northern portion (with the exception of the western part) is formed of a mixture of hard and soft cellular, slightly ferruginous ore of good quality, but towards the southern boundary the fragments of ore on the surface are often found, when broken, to have a centre of rhodonite (manganese silicate), or else of partly replaced slate.

A general sample, taken from the whole outcrop, assays (Government Analyst):—

Manganese	42.4 per cent.
Silica and insoluble	16.3 „

The amount of manganese dioxide was not estimated, but, even assuming the whole of the metal to be peroxidised, it could only amount to 67 per cent., which is rather too low for chemical purposes (Mount Morgan).

The northern end of this deposit is very well worth prospecting, for the discovery of a large lode here would be of great value because of the accessibility of the locality.

Clay slate is the country on the eastern side of the lode, while on the west, together with strongly cleaved clay slates, are highly altered ferruginous andesite tuffs, with casts of indistinguishable fossils and lenticular patches of milk-white calcite.

The road to the east of the northern end of the above deposit, and just south of the Central Mill Tramline Crossing, is covered for a distance of 3 chains with small pebbles of very good ore, possibly derived from a small vein or veins running along the road.

Portion 1033, *Walla.*

Six several areas on this portion have received attention, all lying on the continuation of the zone embracing those in portion 856 and the road adjacent.

Some work has been done 10 chains south-west of the south-eastern corner of 856, a pothole 10 feet deep proving a width of 7 feet of clay-stained manganese ore, seemingly bulging to the south in depth. On the western or hanging wall is a 2-feet band of partly replaced slate, but much of the remainder of the ore is fine-looking blue dioxide, containing, however, much sandy clay, and therefore needing hand-picking and washing. The quality of the ore varies greatly within a space of a few inches, but I believe it will improve with depth. The hanging-wall is fairly well defined and vertical, but the footwall is stained and veined with ore. The country on the west is fissile decomposed purplish tuff slate, dipping 70 to 80 degrees to the west-south-west; while that on the east is decomposed massive slate.

The deposit was found by trenching, and, judging from the fragments on the surface scattered over a width of a chain, it may be 3 or even 4 chains long. A sample from it assays (Government Analyst):—

Manganese	40.5 per cent.
Silica and insoluble ...	20.1 „

This is equivalent to, at the most, 64 per cent. of manganese dioxide.

A second smaller outcrop—probably a separate deposit—is to be seen half a chain up the hill to the west, and partly replaced slate half a chain beyond it.

The next is a couple of chains to the east, on the line of that on the road (referred to under portion 856). Fragments of good ore are scattered over the ground for a distance of 2 chains, and a general sample from them assays (Government Analyst):—

Manganese ... ... 47.3 per cent.,

which is equivalent to, at the most, 75 per cent. of dioxide, but all of this is not likely to be available.

The next manganiferous belt is 5 chains west of the pothole, and has a width and a length (south-east) of a chain. Large blocks of rather soft, sometimes quartz-veined, ore, with central pinkish manganese-stained slate (partly replaced) occur half-way between portions 856 and 917, the manganese apparently lying across the belt. The silica will probably decrease with depth. Tuff slate occurs south of the blow.

Some chains south of the last, and within 4 chains of the north-west corner of portion 917, is a large outcrop known as the Big Blow, on the line of the outcrops in portion 856 and that on which the pothole has been opened. Fragments and boulders up to 6 feet in diameter cover an area 2 chains long (north-west and south-east), and a chain across. There are two manganiferous portions separated by about 4 feet of red slaty tuff containing bunches of manganese ore, the south-western about 5 feet wide, the other 3 to 6 feet wide. The dip is about 60 degrees to the south-west, and gradually gets greater with depth. A third outcrop 20 feet to the north-east is 4 feet in greatest width, and consists of somewhat better ore than the others, but, like them, it also passes into jasperoid at the northern end.

A pothole has been opened to 10 feet depth on the two south-western blows, which are shown to be 6 feet thick, and, though very hard on the surface, to soften in depth. The hanging-wall side of the south-western lode contained carbonate of copper stains—the metal having probably been derived from the decomposition of the andesite tuff.

The ore is certainly not good, being slaty and containing white cherty centres. The outcrop may be only a siliceous cap comparable to jasperoid. In fact, the hanging (south-western) wall is red jasperoid, and the country beyond it is yellow indurated clay slate. The country on the footwall is also sometimes jasperised. The country must have been originally very fine bedded (laminated), and is now contorted. A general surface sample assays (Government Analyst):—

Manganese	33.0	per cent.
Silica and insoluble ...	30.2	„
Iron	2.3	„

The available manganese dioxide can therefore not be greater than 52 per cent. in the sample, although specimens have yielded as much as 62.4 per cent. The ore is too siliceous for chemical work, but the silica may decrease below the surface.

An outcrop of similar ore to the above occurs in a gully 3 chains to the east-north-east of the Big Blow, and fragments have been picked up for some distance in the cultivated ground to the north.

Portion 917.

An area of boulders and pebbles of poor ore, 20 feet across and a chain in length (south-south-east), lies 5 chains from the northern boundary about midway between the sides of the portion. The country rock is andesite tuff and breccia. The deposit probably consists of up to 6 feet of partly replaced rock. The ore is very poor; indeed, almost every fragment having a central part of country rock, it is little more than highly stained and partly replaced country rock. Other small outcrops occur a few chains to the south-west and south-east.

The country on the eastern side of the portion is clay slate, dipping at a high angle to the west, and containing traces of manganese at numerous points.

About 25 chains from the northern and 6 chains from the eastern boundary a pothole has been opened on manganese stained and partly replaced clay slates. Tuff slates also occur here. The ore obtained was of no value for any purpose.

Other trenches were opened on stained country a couple of chains to the south, a chain beyond which are a 21-feet shaft and an open cut. The open cut, 30 feet long and 15 feet in greatest depth, was on a bunch of ore dipping south-east. The footwall is mottled, white and yellow sandy slate, the hanging-wall pink pipeclay. The ore passed at a shallow depth into a thin seam of manganese-stained clay. The few tons of ore obtained was of a good quality, a sample of that left on the surface assaying (Government Analyst):—

Manganese ... ... 48.4 per cent.

equivalent, at the most, to 76.5 per cent. of manganese dioxide.

On the one-chain road running north from the north-eastern corner of portion 917 good manganese has been found within 2 chains of that portion. The ore occurred in two over-lapping, north-and-south-striking bunches, 6 and 10 feet respectively in length, making very little outcrop. The ore in the longer northern lens has passed, at 4 feet depth, into manganese-stained material. Some of the ore assayed privately 65 per cent. available manganese dioxide. About 10 tons were obtained, and a sample of that left yields (Government Analyst):—

Manganese	47.2 per cent.
Available manganese dioxide	67.7 ,,
Silica and insoluble ...	8.2 ,,
Phosphorus	0.075 ,,
Sulphur ... trace, less than	0.1 ,,
Iron	0.91 ,,

This is rather too low in available dioxide to be accepted at Mount Morgan, but the silica, phosphorus, and sulphur are all within reasonable limits. The country is yellow clay slate striking north and south.

Portion 1147.

A few blocks of manganese dioxide have been found on the north-eastern corner of this portion in brown soil, clay slate country. One specimen from the best block assayed 74 per cent. manganese dioxide, but the greater part of the ore is very poor, and, besides, most of the blocks have slaty silicate centres. Fragments of impure ore can be traced for a quarter of a mile to the south. At one place, 10 chains from Currajong Creek on the east, and 15 chains from it on the south, a pothole has been opened on jasperoid, with a certain amount of ore dipping 45 degrees to the west. Manganese-stained blocks cover an area half a chain in diameter, the amount of manganese may be expected to increase at depth, while the silica will decrease, so that the deposit is worth testing.

Manganese ore has thus been shown to be abundant in this locality, but so far most of it is of rather too poor a quality for it to be payably worked. Manganese ore, however, very often proves far less siliceous at a shallow depth than on the surface, and trial shafts might be sunk with good prospects of finding payable ore.

Bog Ore.—An impure iron-alumina-manganese ore occurs in the flat coal-measure country north of Currajong Creek, often forming a surface deposit 2 feet thick over considerable areas. The deposit is most likely a residual one, formed by the decomposition and leaching of a now denuded cover of basalt. There is no use for such ore just at present, though a demand may arise at any time for any of the metals contained in it.

KALLIWA.

Portion 5v, *Kalliwa*, is on the south-western side of Kalliwa Creek, 4 miles above the Burnett River, and 23 miles south-south-west of Gingin. In the cultivation of a small plot of ground on this portion, numerous blocks of manganese dioxide and silicate, together with stained slate, were found. Nothing can now be seen *in situ*, and the ore is not of good enough quality to warrant prospecting work even if there were any prospect of there being a large deposit here. Besides, the distance to a railway (14 miles either to Mount Perry or Degilbo in a straight line), and the roughness of the intervening country, would effectually prevent the present exploitation of any deposit of ordinary size.

DEGILBO.

Portion 54*v*.

Boulders of manganese ore occur over a width of 1 to 4 feet, on an east and west line, for a distance of 15 yards, in about the centre of the western part of 54v, Degilbo. Two tons of ore obtained some months ago averaged 69 per cent. manganese dioxide. A sample of the best ore now on the surface assays (Government Analyst):—

Manganese	52.0	per cent.
Available manganese dioxide	68.0	„
Silica and insoluble ...	6.5	„
Phosphorus	0.08	„
Sulphur ... trace, less than	0.01	„
Iron	1.7	„

This is a very good result, and with hand-picking, it should be possible to bring the percentage of dioxide up to 70 per cent., the minimum accepted at Mount Morgan.

The country rock is slate, but on the northern side of the outcrop jasperoid occurs, with bunches of manganese ore.

The cartage to Degilbo Railway Station (3 miles) costs 3s. 6d. per ton.

Other small bunches of good manganese ore are found in the slates at the northern end of the old Mineral Selection 2307 (on which the Commonwealth Mine is situated), a quarter of a mile west-south-west of the above.

WARWICK.

Mount Gammie lies 5 miles west-south-west of Pratten, and about 1½ miles east of Thane's Creek. The summit is 2,200 feet above sea level, and 800 feet above the general level of the surrounding country. The manganese deposit is on the ridge top, 10 chains south, a little east of the trigonometrical station on the summit, and is reached by a timber track from the Gladstone Mine. It is only a couple of miles from the proposed Thane's Creek station on the Warwick-Goondiwindi Railway, now in course of construction; so that, in the event of the ore being worked, cartage would not be a heavy item of expenditure.

The country rock is sandy clay slate and quartzite, striking a little east of north, while the trend of the ore body, which dips to the east, seems to be generally nearer north and south. It is said that only three blocks of ore outcropped, and no other outcrops are known in the vicinity, though strong stains are very prevalent in the Big Hill adit, 2 miles to the north-north-east.

LETTER OF TRANSMITTAL.

Geological Survey Office,
Brisbane, 19th March, 1904.

SIR,—I have the honour to forward, for publication as a "Record," Mr. Etheridge's "Notes on the Occurrence of the genus *Halysites* in the Palæozoic Rocks of Queensland, and its Geological Significance," together with other Notes on various subjects by myself.

I have, &c.,
B. DUNSTAN,
Acting Government Geologist.

The Under Secretary for Mines,
19th March, 1904.

I.—NOTES ON THE TESTING OF CENTRAL QUEENSLAND COAL.

Several tests have been made at various times of the coal in the Dawson-Mackenzie basin, and recently a bulk sample from the mammoth seam, near the Mackenzie River, has been tested by Mr. C. B. MacDonald, the Coal Inspector for the Railway Department. It is stated in his report that the only objectionable feature in the burning of the coal is the formation of clinker and some incrustation in the end of the tube in the firebox. He also states that the coal ignites readily and burns brightly, radiating heat well, and emitting no smoke when properly fired.

The tabulated results of the test, amongst other data, indicate that in one trial 1 lb. of coal evaporated 9.4 lb. of water at 212 degrees Fahr., and that in another trial 1 lb. of coal evaporated 9.7 lb. of water under similar conditions. These results are eminently satisfactory, and compare favourably with the English Admiralty tests of Welsh coals, which indicate, under similar conditions, that on an average 1 lb. of Welsh coal evaporated about 9 lb. of water. The highest results in the tests was obtained from a coal which evaporated 10.7 lb. of water, but a great number of good Welsh coals did not evaporate even 9 lb. of water.

Coal from the Bluff has also been tested by the Railway Department, but Mr. Graham, for whom the tests were made, states that the results were not satisfactory owing to the coal being taken too close to a disturbed area, but that it is intended to proceed with the development of the mine, and to have a bulk sample taken from the seam further away from the disturbance.

Coal from the Central Queensland Coal Syndicate's mine on the Dawson River has been tested by the Admiralty authorties in Sydney, the results of which are given in the following table:—

RESULTS OF TRIAL ON H.M.S. "WALLAROO."

H.M,S. "WALLAROO," AT JERVIS BAY, 29TH DECEMBER, 1903.

—	Anthracite only.	Equal proportions Anthracite and Osborne Wallsend. Forward stokehold.	Anthracite only. Aft stokehold.
Date of trial	7 p.m. to 9·30 a.m., 27-28/12/03	9·30 a.m to 7 p.m.	9.30 a.m. to 7 p.m.
Duration of trial	14½ hours	9½ hours	9½ hours.
Average speed	12·54	12·64	12·64
Coal per hour	44·2 cwt.	16·75 cwt.	27·6 cwt.
Average coal used per I.H.P. ...	2·7 lb.	2·05 lb.	3·2 lb.
Distance run per ton of coal ...	5·6 knots	5·4 knots	5·4 knots.
Revolutions per minute	Sd. 105·48, Pt. 104·4	Sd. 108·8	Pt. 108·29.
Average I.H.P.	1,827	1,827	1,827.
Rate of combustion	Moderate	Moderate	Moderate.
Deposit of soot in tubes	Very slight and of gritty nature	Very slight and of gritty nature	Very slight and of gritty nature.
Emission of smoke (see remarks) ...	Slight	Slight	Slight.
Grate surface in use	1,508	754	754.
Percentage of ash and clinker, approximate	8·4	9·87	10·41.
Maximum temperature of coal boxes under similar conditions	90	90	90.
State of ship's bottom	Fairly clean	Fairly clean	Fairly clean.
Draught of water at beginning of trial	17 ft. 8 in. aft, 16 ft. forward	17 ft. 8 in. aft, 16 ft. forward	17 ft. 8 in. aft, 16 ft. forward.
Force of wind	4 to 5	4 to 5	4 to 5.
State of sea	Moderate	Moderate	Moderate.
Direction of wind relative to ship's course	On beam	On beam	On beam.
Consumption per square foot of grate surface per hour	3·28 lb.	2·5 lb.	4·1 lb.

REMARKS.

(1) Trial satisfactory.

(2) Conditions:—

Nos. 1 and 2 boilers lit up with the anthracite coal: Nos. 3 and 4 with Osborne Wallsend.

In No. 1 boiler one fire-bar was removed from each tier, and fires were lit 12 hours before steam was required for moving.

In No. 2 boiler fires were lit under normal conditions 10 hours before steam was required.

Steam was showing in No. 1 boiler (sufficient to start circulators) in 6½ hours. Steam for connecting up No. 2 boiler was ready in 11½ hours.

As soon as ship was clear of harbour, Nos. 3 and 4 boilers were fired with anthracite coal only, and trial started at 7 p.m.

All draught plates were removed, and steam was regulated by the fan engines, the air pressure varying from three-tenths to five-tenths.

Fires were gradually thickened to about 6 inches, and kept level by using a rake.

It was seldom necessary to use the pricker excepting in the far corners when fires looked dead from ash-pits.

The flames never extended more that 1 to 1½ feet over the surface of the fire.

After steaming for 14½ hours with anthracite coal in forward boilers, an experiment was tried with mixing the anthracite and Osborne Wallsend in equal proportions, with the attached results.

The aft boilers were steamed with anthracite coal only throughout the 24 hours. At the completion the fire-bars were covered with a deposit of white, powdery ash, easily removed, and little clinker.

The clinker found was of a solid nature, 1 inch to 2 inches in thickness, which was easily removed, as it was of a brittle nature.

Details of smoke were taken from the bridge each hour during the night. and its density varied from 0 to 1.

When the mixing of coals was taking place details were taken each quarter of an hour from each funnel, and comparisons made.

They varied from 0 to 2, and from the general result the emission of smoke was practically nil.

JNO. E. HEWITT, Captain.
HAMILTON J. COAD, Engineer-Lieutenant (Ringarooma).
W. H. GLASSPOLE, Engineer-Lieutenant (Wallaroo).

SUGGESTIONS BY ENGINEER-LIEUTENANT COAD.

As this coal is of a non-coking nature, its general adoption by itself would appear impracticable, as it is only possible to burn it under very limited conditions. From past experience with anthracite coal, it is found impracticable to force it over ½-inch air pressure, and likewise it is absolutely necessary to use the fans while burning it. From the results obtained, it would appear an excellent addition to the ordinary volatile Australian coal if mixed in proportions of about three of Australian coal to one of anthracite; for it is inferred that the former would aid the complete combustion of the latter, and in the process of combustion a large proportion of smoke would be eliminated.

From the burning of this anthracite coal, it would appear to be of much the same nature as that which is obtained from South Wales, England, although its chemical analysis, as supplied, does not agree. This may easily be accounted for by the fact that the analyst does not determine his results in the same way as is adopted in the Admiralty Laboratory at Cardiff.

The following remarks on the test were submitted to the Under Secretary by myself:—

"A review of the above table and notes thereon shows that the question of the Dawson coal being smokeless may now be dismissed, as it has been finally and authoritatively answered in the affirmative.

"Regarding the combustion of the coal, there appears to be no doubt that it is rather slow to ignite, and this must be taken as an objectionable feature. The percentage of ash and clinker is satisfactorily low in comparison with that of high-class Australian coals, the latter sometimes reaching double the amount shown in the above table.

"The crucial point about the test is the quantity of coal required to produce a certain amount of steam in a given time. The amount of coal used in the Dawson test is very low, but I am of opinion that even better results can be obtained when the peculiarities of the coal are understood. The engineer-lieutenant states, in effect, that the coal would reduce the tendency of other Australian coals (which under Admiralty conditions are inferior) to make smoke if burned with them: and as New South Wales coals could be obtained more conveniently and cheaper than Dawson coal in the Dawson-Mackenzie coal basin, no doubt the Admiralty would welcome any coal of special quality which would help to burn the coals they can so easily and cheaply acquire.

"So far as the Central coals are concerned, two classes exist, and if it be necessary to mix the Dawson coal—which, by the way, is distinctly and decidedly not an anthracite—with a more bituminous coal, this later class of coal can be supplied either from the Mackenzie River coal or from the Bluff on the Central railway, both producing a more or less caking coal. Indeed, I am of opinion that the coal from the Mackenzie and the Bluff would in themselves produce results similar to a combination of the Dawson and southern coals. I would therefore suggest the next stage in determining the qualities of Central Queensland coal should be to have a trial of the Mackenzie or Bluff coal under similar conditions—preferably the Mackenzie.

"The conditions laid down by the Admiralty, briefly stated, are as follow:—

To generate steam quickly the coal should burn quickly. Water should be converted into steam with a small consumption of the coal.

The coal should not be "bituminous," as such coal makes smoke, and this is objectionable.

The coal should be dense and not friable, to stow compactly into bunkers, and not to break up by movements of the vessel.

It should be to some extent a caking coal, so that the particles cohere when in the furnace—an advantageous quality when a vessel is rolling in a gale.

No coal in the world is known to possess all these qualities."

Judging from the manner in which the word "anthracite" has been used recently, there seems to be a misconception regarding its application. Even in works of reference considerable confusion exists as to how it should be

applied. The percentage of fixed carbon is constantly but incorrectly being used as a basis to determine whether a coal is or is not an anthracite. A coal high in fixed carbon (say, 90 per cent.), and another one with, say, 60 per cent., might each be a true anthracite, although between them there is a difference of 30 per cent. of fixed carbon. Of coals having a low percentage of fixed carbon, an example may be given of one occurring at Hampden, north of Mackay, the composition of which is as follows:—

Moisture	2·4	per cent.
Volatile Hydro-carbons	2·2	„
Fixed Carbon	65·8	„
Ash	29·6	„

The analysis shows nearly 30 per cent. of ash, and the coal is practically useless; but it has every anthracitic feature, including a *very low percentage of hydrocarbons compared to that of fixed carbon.*

The ratio of hydrocarbons to fixed carbon is the important factor in the determination of an anthracite, and as a result of this it is found that, roughly, a coal with less than 10 per cent. of hydrocarbons may be considered an anthracite, while with a slightly higher percentage it would be a semi-anthracite or semi-bituminous coal. An increasing quantity of hydrocarbons graduates it into ordinary bituminous coal.

The amount of fixed carbon is also commonly taken as the basis of the heating power of coal, but a coal may be low in fixed carbon and at the same time produce more heat than an anthracite. This is because of the heat-producing element in its volatile hydrocarbons. Hydrocarbons contain hydrogen, and if there is any available for combustion, which is not always the case, one per cent. of it is found to be equivalent to 4½ per cent. of carbon. A coal therefore having 80 per cent. of fixed carbon and two per cent. of "available" hydrogen in its hydrocarbons would have nearly as much heating power as a coal with 90 per cent. of fixed carbon and no available hydrogen, while a coal with 75 per cent. of fixed carbon and four per cent. of available hydrogen would have a greater heating power than either of the above. New Zealand Westport coal, for example, is not an anthracite but a bituminous coal, having a heating power greater than many other coals which have much more fixed carbon in their composition, this greater heating power being due to the available hydrogen in the volatile hydrocarbons.

In the results of the recent Admiralty trials of Queensland coals no information is given concerning their calorific value. This is to be regretted, as it is as necessary to know how much heat energy is contained in the coals, and how much is being wasted, as it is to know how much is being utilised.

No systematic investigations have been made to determine the economic value of Queensland's resources in coal. The matter is one of increasing importance from a commercial standpoint, and an examination should be made of all the coals of the State. The results should be tabulated and put in a form available to both producer and consumer.

The examination should comprise a number of tests; but the principal ones would be—(1) Chemical analysis, (2) Calorimetric tests, (3) Practical working tests in marine and locomotive engines, (4) Its coke-making properties, and (5) Its suitability for making gas for lighting and heating purposes.

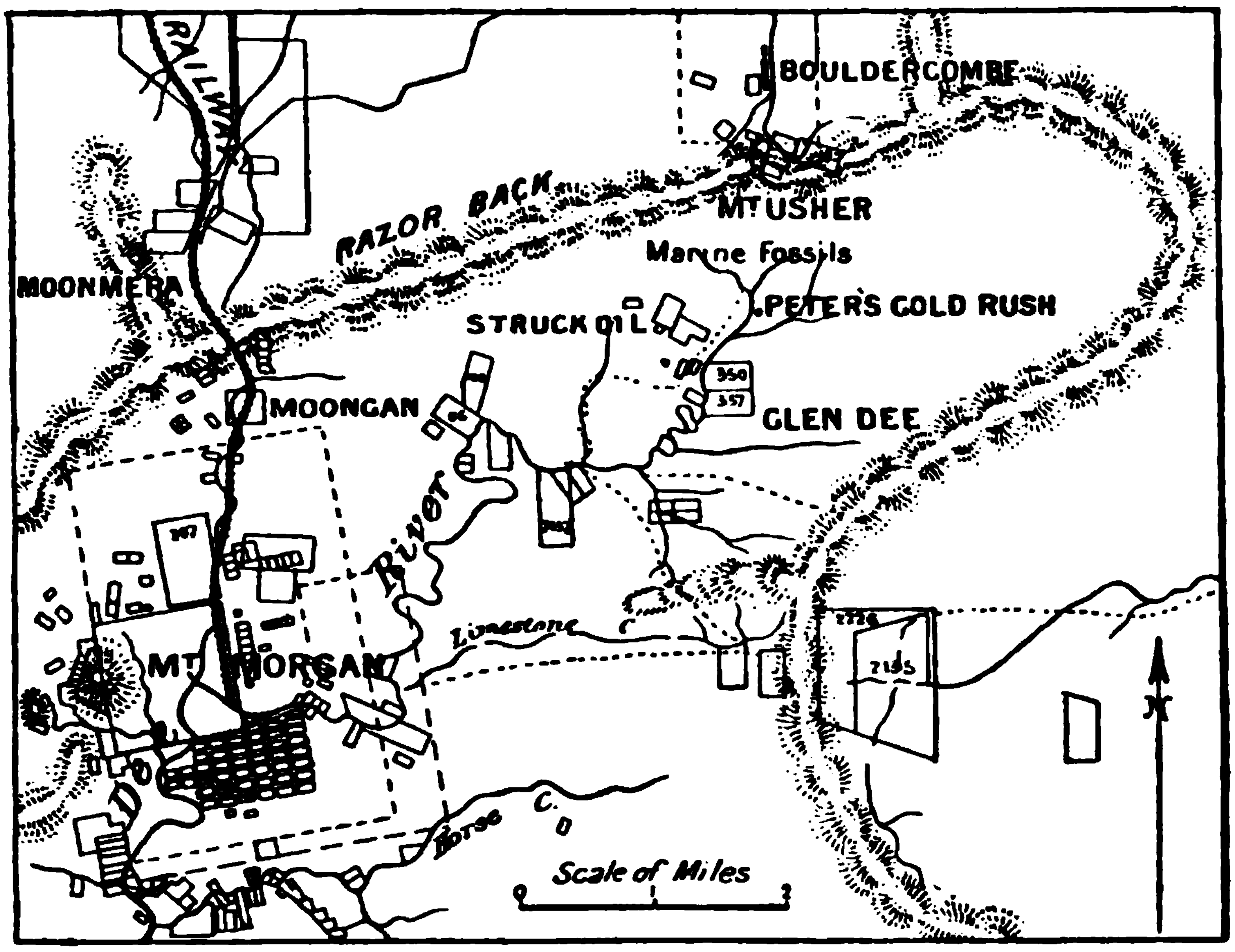
The commercial aspect must not be forgotten, and amongst other things should take into consideration the behaviour of the coal in transit, its liability to spontaneous combustion, the question of convenience to port, and freedom or otherwise of consumption in fireboxes.

II.—NOTES ON THE OCCURRENCE OF GOLD NUGGETS AT THE DEE RIVER, NEAR MOUNT MORGAN.

An inspection on 18th December last was made of the workings on the Dee River, where recently a large number of slugs of gold have been unearthed. The locality is about $4\frac{1}{2}$ miles from Mount Morgan, in a north-easterly direction, and in the vicinity of Mount Usher, as shown in the following sketch plan:—

SKETCH PLAN.

Showing Locality where Nuggets are being found on the Dee River.



The river was in flood at the time of the visit, and many of the workings could not be examined; but sufficient data was obtained, from an inspection of the workings which were not flooded, and also from the workmen, to show the manner in which the gold occurs in the wash, and how it came into its present position During the time of the examination a nugget weighing $85\frac{1}{2}$ oz. was found in one of the claims, and a careful inspection was made of the spot to obtain all the information bearing on its origin.

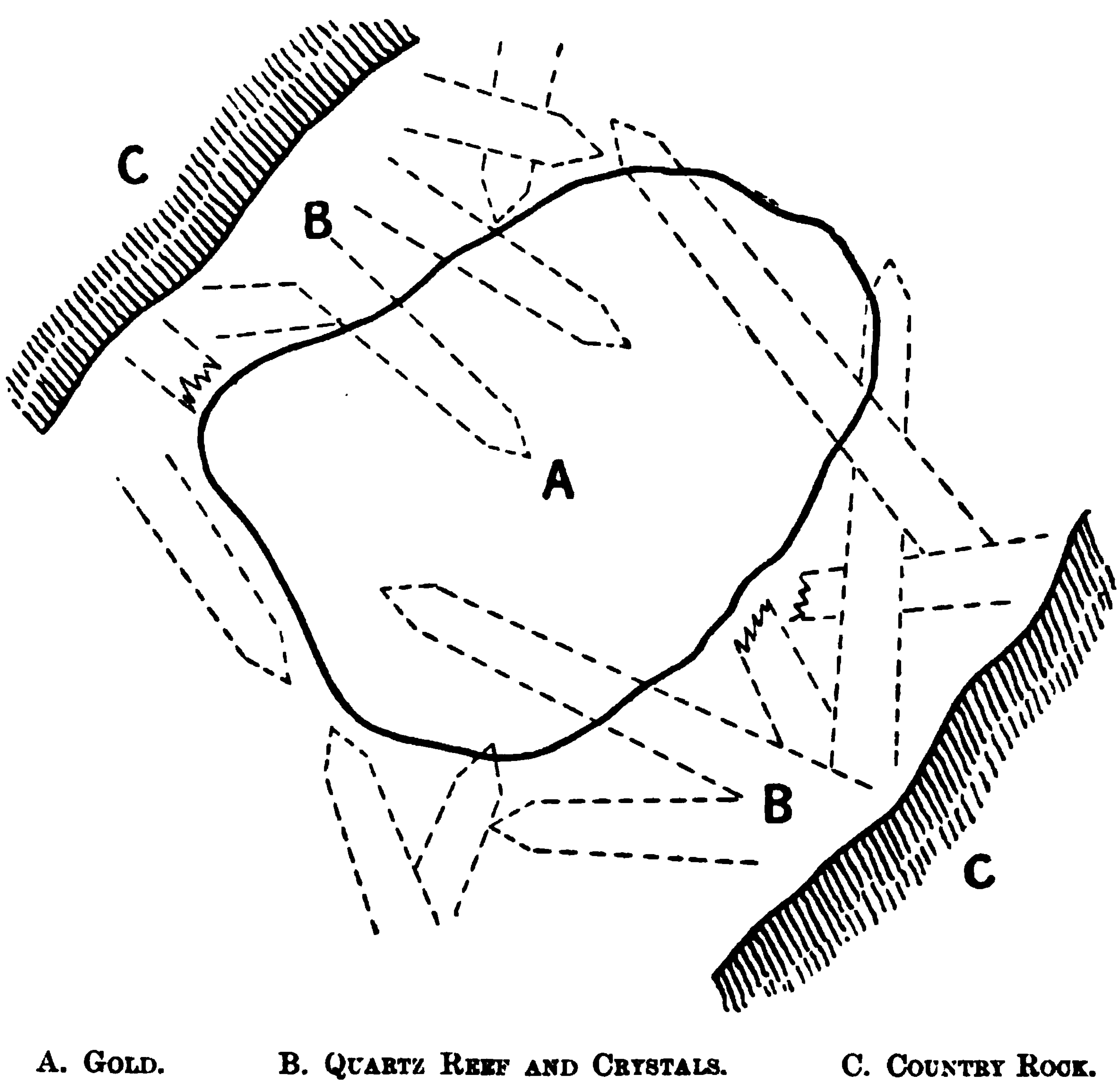
All sorts of theories had been suggested to account for the gold occurring in such coarse pieces, but nothing was seen different to the usual mode of occurrence of alluvial gold. Some of the miners had an impression that the gold was formed in a "mullocky" leader in the adjacent country rocks, and had been washed down to where now it is being found. Others were of the opinion that the gold had been formed into nuggets in the alluvial deposits, or that small pieces had become enlarged by the precipitation of gold on their surfaces.

The latter view was held by a great number of persons because of the frosted appearance of many of the nuggets, and who considered that the alluvial gold, to become frosted, must have received some increment by the precipitation on its surface of gold held in solution. This, of course, need not be so, and the frosted appearance may be, and probably is, due to the action of percolating mineral waters, by which the surface has been etched.

The idea that gold was formed in a "mullocky" leader also had a number of advocates, but the evidence on this point showed conclusively that the gold had formed in association with quartz. The 85½ oz. nugget, on examination, besides showing a frosted surface, was found to be penetrated by a number of six-sided holes. On closer inspection, after the specimen was cleaned, these holes proved to be the casts of quartz crystals, in which all the well-known peculiarities of crystallisation of that mineral were reproduced, showing undoubtedly the gold to have been deposited in a vugh or cavity containing a cluster of quartz crystals. The following rough sketch will show how the gold occurred, and from it the conclusion will be drawn that the size and shape of the gold nuggets were very different when enclosed in the cavity of quartz crystals from what they were when found in the alluvial wash, after being worn into their present form by attrition:—

DEE RIVER NUGGET.

Sketch showing Casts of Quartz Crystals in the Gold, and probable position of the Gold in the Reef from which it was derived.



A. Gold. B. Quartz Reef and Crystals. C. Country Rock.

It may naturally be assumed that a cavity or vugh of quartz crystals occurred in a reef of quartz, and that the reef has been gradually weathered away by the ordinary processes of sub-ærial denudation; and while the gold was

being washed away from the reef and lodged in alluvial deposits, the alluvial deposits or "wash" was forming by the accumulation of detrital material derived from the reef itself and from the country rock in the vicinity.

There is very little hope of finding the reef which contained the gold, as many changes have taken place in the configuration of the country since that time; and if a reef containing very rich gold were discovered close by one would be very much inclined to think it had quite an independent existence to the reef from which the gold recently found has been shed.

The prospect of finding a continuation of the lead above or below the present workings is a matter of concern to the miners; and, although further discoveries of gold may take place, no favourable feature was observed during my short visit to indicate any great extension of the field. The confined space between the hill in which the lead occurs and the disturbance of old leads by recent encroachments of the stream, together with the formation of recent deposits from old ones, are considerations which make it impossible to determine the direction of the lead in which the gold has been deposited, until the gold has been actually found. The information which might have been obtained from a longer inspection cannot be conjectured: but, while nothing was observed to indicate the permanence of the field, the character of the rocks in the country round about shows that similar deposits might be found having no connection with this one on the Dee River.

A quartzite formation in the vicinity has been found to contain gold, and was thought by the miners to have some connection with the alluvial gold found in the bed of the river. This formation is not a reef, but an altered sedimentary deposit impregnated with gold-bearing pyrites, and consequently has quite a distinct origin to a quartz reef in which such massive gold specimens were formed.

Mention may also be made of the character of the bed-rock on which the gold has been found, in view of the opinion expressed that it might have been the matrix of the gold. In many of the claims the bottom of the wash is a clay, in which some of the gold nuggets were partly embedded, while in other places the bottom is a decomposed shaly sandstone rock. In the decomposed bed-rock some fragments of marine fossils were discovered, which indicated the strata here to be "Gympie" formation of Permo-Carboniferous age. The surrounding country appears to be made up of a variety of rocks of similar formation with intrusions of acidic and basic igneous dykes.

III.—PHOSPHATE-BEARING ROCKS IN THE ROCKHAMPTON DISTRICT.

Reference was made in the Progress Report for the year 1897* to the presence of a phosphate of alumina in the altered slates at the mouth of Cawarral Creek and on the islands of Keppel Bay. Since that time the advantage of knowing more about phosphatic deposits has induced further attention being paid to their occurrence, and the results of an examination of other islands and of the mainland on this part of the Queensland coast shows that phosphates, in association with altered slate rocks, occur at Emu Park, Yeppoon, Curtis Island, and Quoin Island to the south of Curtis Island. These localities are shown in the following sketch map:—

KEPPEL BAY AND ENVIRONS.

Showing Position of Serpentine, Limestone, and Slate, and Phosphate-bearing Slate Belts.

The slate country seems to occur as a belt trending north-west and south-east, and extends from Facing Island to beyond Yeppoon. The rocks in this belt consist of ferruginous, clayey, and quartzose slates, which are more or less altered and contorted, and contain masses of chert and quartz, while in

* Annual Progress Reports for the years 1896–1898. Brisbane: By Authority, 1899; pp. 14 and 16.

places they are traversed in all directions by fine quartz leaders. The phosphates occur usually as apatite, the yellowish and brownish lime phosphate; but turquoise, the bluish and greenish alumina phosphate, is also occasionally found.

The deposits on Keppel rocks were prospected by Mr. E. K. Ogg, of Rockhampton, and from a quantity of phosphate rock in his possession the writer took an average sample for analysis. This yielded at the rate of 14 per cent. of phosphoric acid, being an equilavent, roughly, of about 40 per cent. of lime and alumina, the result not being considered satisfactory. The sample, however, is from one of a number of places along the coast where phosphates are known to occur, and encourages us in the hope of finding something better.

At Quoin Island Mr. Ball has found turquoise as small irregular masses and veins in ferruginous and quartzose slates, but the occurrence of other phosphates was not noticed.

At Olsen's Caves, about 16 miles in a northerly direction from Rockhampton, an investigation has been made to determine the extent and richness of the bat guano deposits known to exist there. An illustrated description of the caves has been published by Mr. J. Christensen, Danish Consul,* showing the possibilities of making the working of the deposits a profitable undertaking. Some exploratory work has been carried out under his directions, showing that the deposits were extensive, and contained in places pure phosphate of lime, but the results were not encouraging, and work was suspended. Every endeavour should be made to have the cave deposits thoroughly prospected in view of the value a good deposit of bat guano would be for agricultural purposes.

* Olsen's Caves, near Rockhampton. By J. C., in Q.G.M.J., 1903, p. 572.

IV.—THE IRON BONUS COMMISSION—EVIDENCE TAKEN IN QUEENSLAND.

The Royal Commission on the Federal Bonus Bill held three sittings in Brisbane on 1st and 2nd May, to take evidence bearing on the occurrence of iron ore deposits in Queensland. Those examined were Captain Richards, general manager of Mount Morgan; Mr. W. Fryar, Chief Inspector of Mines; Mr. L. C. Ball, Assistant Government Geologist; Mr. J. Hargraves, mining surveyor of Ipswich, and myself.

The information accumulated by the officers of the Geological Survey was obtained under difficulties, but most of the localities have been visited where minerals used in the production of iron are known to occur, and the results of these inspections was of the greatest value for the purpose in view. The report of the Commission has been published, and a reprint appears in the *Government Mining Journal* of 14th November, 1903.

It is only since the inquiry that public attention has been drawn to the natural facilities possessed by Queensland for iron manufacture, and the almost boundless resources in iron, coal, limestone, and other accessory minerals on her eastern seaboard. A perusal of the accompanying plan and table will show the locality of some of our minerals, and their position with regard to centres at which works might be started.

The following is a summary of evidence taken by the Iron Bonus Commission at the Brisbane sittings:—

SUMMARY OF EVIDENCE.

The Federal Royal Commission, appointed to inquire into the question of the proposed establishment of the iron manufacturing industry in Australia by means of a Government bonus, held three sittings in Brisbane—two on the 1st May and one on the 2nd. The Commission had previously taken evidence in Melbourne and Sydney, and the sittings were held here during the recent visit to Queensland of its Chairman (Hon. C. C. Kingston, Federal Minister for Trade and Custom). Besides Mr. Kingston, the other members of the Commission present were: Mr. L. E. Groom, Federal Member for the Darling Downs (Q.) and Mr. David Watkins, Federal Member for Newcastle (N.S.W.). Appended is a summary of the evidence taken:—

Mr. Dunstan's Evidence.

Benjamin Dunstan, F.G.S., Acting Government Geologist, of Queensland, examined by Mr. Kingston, stated that he had been in the employ of the Queensland Government for the past six years. Asked as to whether he had formed an opinion as to the prospect of the successful establishment of the manufacture of iron and steel in Queensland, he said he had formed an opinion on that subject as far as it related to the deposits of iron, limestone, coal, and other minerals necessary for that purpose. From the quality, locality, and extent of the iron ore and coal deposits, as well as the availability of fluxes, he was satisfied—indeed, had no doubt in his mind—as to the prospect of successfully establishing such an industry in this State. From a commercial point of view, he could not express an opinion, but as far as the requisites for the manufacture of iron were concerned, it seemed to him there was everything

that could be desired. The materials that were needed were readily accessible, in some districts were within a short distance one from the other, and from this point of view everything was in favour of the successful establishment of the iron industry. There were many large deposits of iron known to exist in Queensland. He had prepared a plan and table showing some of Queensland's ironstone, coal, and limestone resources (which he tendered to the Commission). This diagram included deposits within a reasonable distance of the eastern coast, and gave details of their locality, extent, and the quality of the ore. There were other deposits, but they were not convenient to the seaboard, and he would give particulars of those not included in the diagram. The particulars given in that diagram had been carefully checked in his office, and could be relied upon as being correct.

Speaking of iron ore, Mr. Dunstan said there were a great number of deposits in Queensland. Particulars had been prepared altogether of about a dozen. There were a number shown on the map representing the eastern coast of Queensland, and in addition to these there were others not shown. These latter occurred inland, and comprised Mount Leviathan, Kangaroo Hills, Wild River, and Mount Lucy, all containing valuable deposits of ironstone. Mount Leviathan was at Cloncurry, 250 miles from Normanton (on the Gulf of Carpentaria), 210 miles from Winton, where coal occurred, and 550 miles south-west from Townsville. Normanton was the nearest port. The nearest railway was at Croydon, but a railway from Cloncurry would be most likely to go to Normanton direct. In the same locality as Mount Leviathan there was abundance of limestone, and at Cloncurry there were immense deposits of copper. As to the extent and quality of the iron ore deposit at Mount Leviathan, Dr. Jack (late Government Geologist), in Bulletin No. 10 of the Queensland Geological Survey Publications, said that the hill consisted of "a mass, say 200 feet high, and a quarter of a mile in diameter at its base, of the purest possible iron ore The greater part of it is massive or granular iron ore, with only a few grains of siliceous sand. Specimens of foliated specular iron may be picked up, and parts of the mountain are of magnetite. The specular iron is frequently magnetic." As to the quality of the ore, he had no analysis further than that obtained by Dr. Jack, but it would be observed that he described it as "the purest possible iron ore." As to the quantity, taking the height as 200 feet and the diameter 1,200 feet, and without going below the base of the mountain, they had 10,500,000 tons of hæmatite. In the same locality was a smaller hill—Mount Pisa—of one-tenth the capacity of Mount Leviathan, which would practically give another 1,000,000 tons—or a total of 11,500,000 tons. The two mountains were two miles apart, and possibly were connected by subsidiary deposits which outcrop in various places between them. Mr. Cameron, Assistant Government Geologist, in the notes already presented to the Commission, had given particulars of these deposits. (See *Government Mining Journal*, March, 1903, p. 126). He (Mr. Dunstan) had seen a private letter from Dr. Jack, who was now in London, in which he reiterated the description which he had previously given of these Cloncurry deposits. With regard to Kangaroo Hills, a report had been made on this as a mineral field, but Mr. Ball, Assistant Government Geologist, who was also to give evidence, would give a review of it later on. The information available concerning the deposit on the Wild River was from a report by Dr. Jack. As to its position, it was 80 miles directly south-west of Cairns, and was reached by rail to Mareeba, 46 miles, and thence 60 miles, *viâ* Herberton, by road. In a report written in October, 1898, Dr. Jack had described this deposit as "a large lode of pure magnetic iron oxide." Mount Lucy was about 80 miles south-westerly from Cairns on the Chillagoe Railway This also had been reported on by Dr. Jack in a "Report on the Chillagoe Mining District and

Projected Railway" (Bulletin No. 9, Geological Survey of Queensland, p. 16). He states that "On the top of this hill is an enormous outcrop of exceedingly pure magnetite," and that "the purity and abundance of the ore of Mount Lucy cannot be questioned."

Limestone deposits, Mr. Dunstan stated, were found at Mortar Island, Marble Island, Mackenzie River, Mount Etna, Fitzroy River, and Cloncurry. Mortar and Marble Islands were opposite Broadsound, 40 miles north-east of St. Lawrence, 150 miles north from Keppel Bay, Broadmount, and Port Alma. On Mortar Island there was an inexhaustible quantity of the purest limestone. The information he had obtained regarding this deposit was the result of practical working tests by Messrs. James Campbell and Sons, of Brisbane. This was to the effect that it contained 98 per cent. of carbonate of lime, while the stone was, in places, a beautiful saccharoidal marble, and free from clay and silica. Boats loading 500 tons could be comfortably berthed alongside the island, while a jetty could be very easily made to ship stone. Mr. Campbell had given him an approximate estimate that, with a jetty constructed, limestone could be shipped on board a vessel at the island for 2s. per ton. The Mackenzie River deposits of limestone occurred close to the junction of the Isaacs and Mackenzie Rivers, and within 60 miles of the St. Lawrence. If a railway were constructed from the Mackenzie River coal beds to St. Lawrence, it would pass through these limestone deposits. As to the quality, it was siliceous, but the deposits were not explored at the time, and probably places could be found where the limestone was free from silica, as here the silica only occurred where the limestone was fossiliferous. The limestone deposits at Mount Etna, near Rockhampton, were practically inexhaustible. No analysis had been made of it, but large quantities had been used for lime-making for a great number of years, which was a pretty good indication that there was not too much impurity in it. The deposit on the Fitzroy River was 200 yards from the bank of the river, and about four miles north of Rockhampton. The analyses showed a high percentage of carbonate of lime, but the analysis was not complete. Magnesia was present, but the percentage has not yet been estimated. As to the Cloncurry limestone, Mr. Ball was making some extracts from the official reports, and these would be submitted later on in the sitting.

Witness next spoke of the coal deposits of the State. Asked what were the chief deposits, he said there were the Styx River coal, the Mackenzie River coal, the Dawson River coal, the Callide Creek coal, and that of the Burrum and Ipswich districts. These were on the eastern coast, and low down on the coast, but there were other deposits further north and inland which had not been investigated. Asked as to whether there were any recent discoveries of coal, Mr. Dunstan said there were semi-anthracite deposits on the Dawson and a highly bituminous coal deposit on the Mackenzie River. The official tests which had recently been made of the Dawson coal showed that it was anthracitic in quality, and was non-coking; but the test that had been made of the coal away from the banks of the Mackenzie River submitted to the Mines Department by the Mammoth Coal Company, working at the Mackenzie River, indicated that the whole of the 20-feet seam is not an anthracite, but a coking coal of magnificent quality, having a very small percentage of ash (6.5), and a very high percentage of fixed carbon (77.5). The best coal for iron smelting was undoubtedly a coking coal, producing a firm coke, but anthracitic coal was also very valuable for the same purpose. Practically it had been found that anthracite could be used for iron smelting, and in America immense quantities of iron were produced with the use of this coal. The Geological Survey records showed that at the Styx River there were 150 square miles of coal country. These records were contained in a report (No. 84) by Mr. Rands, late Govern-

ment Geologist, on the "Styx River Coal Field." An analysis from one seam seven feet thick showed 11 per cent. of ash in the coal, which made a firm coke. A 15-inch seam showed 3.8 per cent. of ash, but the coal would not coke. A test of the coal made on the Central Railway, and recorded in the above report (page 10), showed good results, and that it was a good steam coal with little ash. Regarding the coal in the Winton bore, quoting from official records, Mr. Dunstan stated that its position was 130 miles south-west from Hughenden, about 210 miles south-east from Cloncurry, and 360 miles south-west from Townsville. Several small seams had been reported, but there was nothing to indicate anything larger than a two-feet seam. Several smaller seams than that had been found in the bore. The quality showed 50 per cent. of fixed carbon, 46 per cent. of volatile hydrocarbons, and five per cent. of ash. It did not form a coherent coke. He could not say whether it would make a good smelting coal, as the sample that had been tested had been too long exposed; otherwise, the percentages showed a very fair coal, and possibly a fresher sample would give more satisfactory results. The position of the Mackenzie River coal was 80 miles from St. Lawrence (Broadsound), and 40 miles added to that would give the total distance from the Mackenzie coal deposits to the Marble Island iron ore as 120 miles. A railway could be constructed to the coast over dead-level country, except where it would cross the Broadsound Range, while the length of the line would be less than 100 miles. The coal outcrops on the Mackenzie River, and had been traced for ten miles. If it extended over only that distance —and his opinion was that it was vastly greater in extent—the estimated quantity of coal available would be 200,000,000 tons of coking coal. The width of the seam was given as 20 feet. A prospecting company had a lease of the country, and they were trying to trace the outcrop towards the Central Railway. He had no doubt that it would ultimately be found on the Central Queensland Railway. The quality of the coal was shown in the plan and table exhibited to the Commission, and indicated a very high percentage of coke. The Ipswich and other southern coal did not give 60 per cent. of coke on an average, whereas this ran up to over 80 per cent. in laboratory tests. While the coal in the 20-feet seam yielded 82 per cent. of coke, which contained 11 per cent. of ash, three feet of that seam had only 7.7 per cent. of ash in its coke. and the coal produced 84 per cent. of coke. Speaking generally, the deposit was magnificent in quality, while the quantity was inexhaustible, if coal could be said to be inexhaustible. In a report on these coal measures—"The Geology of the Dawson and Mackenzie River," with maps and plates—written by himself (and which would be handed to the Commission), he had estimated 5,000 square miles of country to be coal-bearing, and there were possibly other outcrops not yet discovered. The particulars with regard to the Dawson River coal were shown pretty clearly in the plan and table referred to, and details were furnished in the Dawson-Mackenzie Report. A remarkable feature of this coal was its uniformly low percentage of ash—4.8 per cent. Particulars regarding the Callide Creek coal deposits were also shown in the plan. It was a non-coking coal, of extra fine quality, and the quantity was estimated by Mr. Rands to be 50,000,000 tons. It had been worked under lease, but he understood negotiations were now in progress for its purchase by an English company.

By Mr. Watkins: The estimate had been made by an officer of the Geological Department, who had visited the field and inspected the shafts. The quantity was easy to estimate, because the seam was so regularly bedded. From its surface the depth of the coal was about 40 feet or 50 feet, and the thickness of the coal passing through the various shafts was about 21 feet.

Mr. Dunstan, continuing his evidence, next referred to wolfram and molybdenite, minerals very valuable in steel manufacture, which he said were now being exported from Thornborough, on the Hodgkinson, in North Queensland. In 1902, eighty men were employed in mining for these minerals, and the value of the output was £6,793. Chromite and manganese were also valuable in steel manufacture. Chrome ore was found in a belt of country extending from Keppel Bay north-westerly to Marlborough. It was in innumerable patches, spread over a large area, but the quantity in each case had not been shown to exceed 100 tons. One gentleman had stated that a deposit exists which was said to be a mountain of chromite and ironstone, but as it was not protected he would not divulge its locality further than that it is in the heavy country to the north of Rockhampton. As to the quality, analyses had been made, and from those available the stone had been shown to contain about 50 per cent. of sesquioxide of chromium, but the average very probably would not be over 30 per cent. Deposits of manganese had been found at Mount Crosby, nine miles from Ipswich, on the Upper Brisbane River. Some of these had been examined, and analyses indicated the mineral to be very rich. There were numerous outcrops in the locality. The deposits were most irregular, but masses of 100 tons and less were known. One deposit analysed showed about 50 per cent., and another (said to contain 100 tons) 70 per cent. of manganese dioxide. Manganese had also been found at Balcomba, 50 miles west of Rockhampton, and 18 miles north of the Duaringa Railway Station on the Central line. The deposit was difficult of access, being in mountainous country. A quantity of 500 tons was actually exposed on the surface in irregular deposits, but easily mined. No analysis had been made, but the ore was estimated to contain 50 per cent. of manganese dioxide.

Asked as to whether the Queensland coal was being largely used, Mr. Dunstan said the deposits of which he had the highest opinion were not being used. The Ipswich and Burrum coal was being used for ordinary steam, but not for metallurgical, purposes. He thought coke could be produced at Ipswich suitable in every respect for the smelting of iron. Queensland imported some coal from Newcastle. Nothing had been attempted in Queensland in the direction of the manufacture of iron. Experiments had been made with the ironstone from Iron Island, and these experiments had been very successful in producing iron that has been worked up in the shop, but only as a specimen. Speaking generally, and looking at the plan and table which he had prepared, Port Alma could be taken as a centre of a circle having a radius of 145 miles, and within that circle could be found all the minerals or materials (except wolfram and molybdenite) necessary for the manufacture of iron and steel, while wolfram and molybdenite were obained at Thornborough, west of Cairns, Northern Queensland. From a geological point of view, there was no reason whatever why the iron manufacturing industry could not be successfully established in Queensland.

By Mr. Groom: No complete survey had yet been made of the iron deposits of this State, but Mr. Ball, an officer of the Queensland Geological Survey, was now, and had been for some months, engaged in examining the iron deposits throughout Queensland. As the work progressed, it was found that the deposits were so numerous, and were spread over such a large area, that the task would occupy a much longer time than was at first anticipated. Those already enumerated were in close proximity to centres of population; but there were vast areas of Queensland still unexplored, and it was hardly possible for these to be examined without fresh deposits being discovered. The Pittsworth deposits had not yet been inspected, but they would ultimately be

examined in detail. The estimates which he (Mr. Dunstan) had given were the minimum—very low and cautious estimates, and by no means represented the quantities which might be obtained.

West Moreton Witnesses.

Joseph Hardgreaves, mining surveyor, residing at Ipswich, and representative of the Ipswich and West Moreton Mining Managers' Association, examined by Mr. Groom, stated, with regard to the Ipswich coal beds, that the developed country would be about 120 square miles in extent, while there was, he thought, five times that area undeveloped. So far they were only on the fringe of the coal, and had not gone to any great depth. As to the quality of the coal, there were several seams that were particularly suitable for coking—those on the north side of the Bremer River. Some of this coal had been tested, and had been found to be equal to, if not better than, any in the world. His opinion as to the possibilities of the output was that it was unlimited. There were at present 21 seams being worked separately, but it was possible some of these might be found to be one and the same. This coalfield produced about 360,000 tons last year. Working under present conditions, and without the expenditure of any further capital, three times that quantity could be turned out. He read several certificates from experts and others, including Professor Pepper, as to the high quality of the Ipswich coal. The coal had been used for smelting purposes at Broken Hill. There were several deposits of siliceous clay and limestone in the Ipswich district. One thing in favour of the Ipswich deposits was that they could be worked with small capital. Coke made from Ipswich coal had been found suitable for smelting—none better.

By Mr. Watkins: He thought large quantities of the Ipswich coal were sent to Broken Hill, but the freight told against it. There was no objection to the quality. The reason no more coal was put out was because there was not sufficient demand for it. Coal had been imported from Newcastle into Queensland, but last year the quantity was only six per cent. or seven per cent. of the total consumption. The reason for this importation was because the same freights had been charged to the north from Newcastle as from Brisbane, and because ships going from the south to the northern ports of Queensland for fruit, and having little forward loading, carried New South Wales coal as ballast, and sold it cheap on the ship's account. West Moreton coal had been exported; some had been sent to Valparaiso. The difficulty had been the want of special facilities for quick loading, but these had been much improved of late. On the Queensland railways Queensland coal only was used; they would not take anything else. The price of the best coal was, he thought, from 7s. to 8s. per ton. Ipswich coal could be supplied at the pit's mouth at 6s. 8d. per ton. The reason why it could not compete with Newcastle coal at 11s. was because there was not the same shipping facilities.

By Mr. Kingston: The average earnings of the Ipswich miners, working full time—7 o'clock till 4 o'clock—were £2 10s. a week. Miners were paid from 2s. 10d. to 3s. 9d. for hewing and wheeling, according to the character of the seams worked. The men were now hardly working more than half-time—a great many of them were not earning more than £1 5s. per week. From year to year they averaged quite three-quarter time. It was a time of depression now, and one result was that many men were leaving the district.

William Bendley, who stated that he had a knowledge of the iron ore deposits of the Ipswich district, said there were seven lodes covering an area of about 730 acres. The lodes averaged from three feet to four feet in thickness, but he did not know anything as to what they would assay. He produced a sample of iron ore, and said there were several as good as that. He had had no practical experience in the mining of iron.

Mr. W. Fryar's Evidence.

William Fryar, Inspector of Mines, Southern Division, questioned by Mr. Watkins, said he had held the position of inspector of mines under the Queensland Government for twenty-one years. During the first year of his service he was inspector for the whole of the colony, but after that only for the Southern and Central Divisions, where all the coal mines except one were situated. He was of opinion that the coal produced in Queensland was suitable for the smelting of iron ores. He had seen coke produced from it; and he thought the coke from coal obtained on the north side of the Bremer, at Ipswich, was equal to any that could be produced in the southern hemisphere, while it could be still further greatly improved by washing. He had not actually seen the coke used for smelting, because there had not been any smelting operations carried on here, except at Aldershot. Asked as to the extent of the coal fields of Queensland, he said those of the Central district were said to contain 40,000 square miles. The Southern district had been opened up to the extent of 120 to 150 square miles. He produced a list of thirty-one mines, twenty-five of which were in the Ipswich district, three on the Darling Downs, two in the Wide Bay district, and one at Clermont. Four of these were idle. Practically the same coal measures extended from a short distance west of Ipswich to the Darling Downs. The question whether coal was near enough to the iron ores to allow of the latter being successfully manufactured depended greatly on the cost of carriage. For instance, the distance from Ipswich to the North was considerable; but if the coal measures were in the immediate vicinity of the ore, the position would be much more favourable. Of the iron ores of the Ipswich district with which he had come immediately in contact, he had not formed a favourable opinion, but that was a matter that came more within the sphere of the geologist. He had seen no large beds of ironstone in the immediate neighbourhood of the coal seams of Ipswich. The Styx River coal was in close proximity to the iron ore of Iron Island, and would be near enough to warrant their being worked together. Then there were not only iron and coal, but limestone also, in close proximity, and he certainly thought that in that locality there were all the essentials for the successful establishment of the iron manufacturing industry. One reason why nothing had been done in this direction hitherto might have been because the demand had been too limited. It was only recently that our productions could go into the other States without paying duty, and the State market was not sufficient. An Australian market was a different thing. In the Ipswich coal mines, from 1,000 to 1,300 men were employed—about 1,000 below ground. The output of coal had increased regularly, with some variations, since Separation. The production during the past four years has been: 1899, 494,009 tons; 1900, 497,132 tons; 1901, 539,472 tons; 1902, 501,531 tons. The reason for the falling off last year was the same as had operated in other industries—the general depression; and because steamers, having little freight for the North, had carried coal from Newcastle at low rates. He thought the establishment of ironworks would increase the output of coal. He did not think it would help us much to establish works in the southern States, but he was speaking of the Commonwealth generally. He could not say whether it would be possible to establish ironworks here without assistance from the Crown. He certainly thought to establish such works in the State would be a benefit to the State. Very little coke had been sent from here to Broken Hill. There was no other loading except the coke, and that made the carriage very costly. We had no reason to fear that iron smelting could not be successfully carried on with our coal; on the contrary, the coal was of a superior quality for the purpose, and he thought it could be vastly improved by washing.

Captain G. A. Richard's Evidence.

Captain Geo. A. Richard, Metallurgical Engineer of the Mount Morgan Gold Mining Company, was the next witness examined. Questioned by Mr. Kingston, he stated that he had had about twenty years' practice, and had had considerable experience in metallurgy, including iron and steel. He was in a position to express an opinion as to the prospect of successfully establishing iron and steel works in Australia. In 1901 he visited the United States, and was all through their iron and steel regions. He went with a special object connected with the Mount Morgan Company, but took the opportunity of studying the iron and steel industry from end to end—from the mine, through the transport, to the manufacture of iron at Pittsburg. He also visited the works at Colorado. While in America he also obtained all the statistics he could get relating to wages, the distances over which the raw material was railed and shipped, and especially as to the cost of manufacture. He was therefore in a position, with his knowledge of the resources of Australia, to compare the prospects in Australia with actual experience in the United States, and his opinion was that iron and steel could be successfully manufactured in this country. Since he had come back, knowing that he might be required to give evidence before the Commission, he had carefully looked into the question and gathered further statistics, and he was quite satisfied on the subject. When in London, during his recent trip, he discovered that two propositions were before investors for establishing iron and steel manufactories in Australia, and he had an opportunity of going through the reports of experts on those propositions, with the result that those reports confirmed the opinion which he had already formed. He estimated that the cost of producing a ton of pig iron at Pittsburg varied from 32s. per ton to 38s. or 40s. per ton. That was the cost of production. As to the cost of producing steel, he had not gone into that sufficiently to give a precise estimate, but, roughly, he would put it down at about half the selling price. The price of the pig iron varied, but the statistics which he had with him gave the lowest price in America as £1 15s. 4d., and the highest £3 19s. 2d. The Mount Morgan Company paid for pig iron landed in Keppel Bay in 1901, £5 5s., £4 15s., and £5 5s. per ton for different shipments. As to the relative cost of steel, when pig iron cost a certain sum steel proportionately cost so much more. On an average, when the selling price of pig was £1 11s. 10½d., steel was £3 6s. 9d. That was a good average rule—that steel practically cost twice as much as pig iron. Those prices were at the factory; pig iron was generally bought f.o.b. in America. As to the cost of a ton of pig landed in Australia, he could not give anything closer than the Mount Morgan figures. He was satisfied that pig iron could be produced in Australia at the same price as in America. He spoke from his knowledge of the iron and other mineral resources of this country, and he had compared the conditions of the two countries piece by piece—wages, cost of living, cost of transport, cost of coal and coke, and so on. He was speaking of Australia generally, and that included Queensland generally, although not specifically. In Australia the coal and ore were much nearer the seaboard than in America. As a rule, it was better to take the ore to the coal than the coal to the ore, although sometimes there were conditions —such as return loading—which formed exceptions. The iron and the coal were very rarely close together. There were only two instances in the world where iron and coal were found close together in large quantities—in England and Alabama. The wages throughout the iron regions of America were very similar to those paid in Australia. About 1s. an hour was the average of the iron workers in America. He had not worked out exactly the cost of producing a ton of pig in Australia, but it would probably be from 38s. to 40s.—

practically the same as in America. He was satisfied there was no reason why it could not be produced at about that cost—a little more or less; and there was nothing to lead him to doubt why it could not be placed on the market in Australia at the same price as it cost in America. In forming that conclusion, he considered the cost of materials, &c.—iron ore, coke, limestone, manganese, labour, and sundries. The different costs of producing a ton of iron in Australia should be, approximately—1.8 tons of iron ore at 5s. 6d. per ton, 10s.; half a ton of fluxes, 4s.; labour, 5s.; repairs, 3s.; sundries, 3s. That would be under the most favourable conditions, and he had not allowed anything for interest on the cost of plant or for management, which were allowed on the American estimate. These items, in the case of a large output, would come to a very small sum—possibly 1s. or 2s. per ton would be sufficient.

Asked whether he recognised the necessity for a bonus to assist the establishment of the iron industry, Capt. Richard said he did, and stated that, without such assistance, it was very hard to get people to have anything to do with it. He had made it his business to talk the matter over with men of capital in London, and he found they had got it into their heads that wages were high in Australia, that labour conditions were unsatisfactory, and that these elements made it risky to invest capital here, especially in new enterprises. He believed the offer of a bonus of £250,000 would induce the embarkation of the necessary capital—that it would assure a certain result. He believed the requirements of Australia in the shape of manufactured iron would be about 200,000 to 300,000 tons per annum. Works to produce that quantity would not be a very large works, and would cost something between £750,000 and £1,000,000, although that would depend upon certain conditions—such as whether the works provided their own freight steamers and built branch railways. He also called the attention of the Commission to the way in which the world's demand for iron was increasing, and presented some statistics in proof of his statement.

By Mr. Groom: As to what were Australia's chances from this demand, he thought there was going to be a very big demand in the East, that Australian works would not only be able to supply Australian demands, but compete with the United States for the Eastern trade.

By Mr. Kingston: There was only one works in the Pacific Ocean, at Japan. Australia could compete with America, because her works could be put at the seaboard, while the Americans had to pay 9s. per ton to get their ore to port. Germany had low wages, but low-grade ores and high cost of transport. The United States, too, had heavy royalties to pay. Australian ores were better than the German, and were equal to the American, with carriage in favour of Australian. He was satisfied that economic conditions favoured Australian works as against German or American. When he was in America the people there were searching the Pacific slope for material to supply the Eastern demand, but the result, he believed, was very unfavourable. One reason why a bonus was necessary to overcome the "inertia" of capital as far as Australia was concerned was that large capitalists in America and Europe had their money invested in railways, vessels, &c., and they naturally preferred spending their money where their present undertakings existed. Here we had not that huge capital that existed in other places, and we needed to offer special inducements to overcome the "inertia" of which he had spoken. The demand was increasing so rapidly that new works would have to be erected somewhere. While it was a fact that some works had been closed down, others had taken their places in more favourable positions, and under very much more favourable conditions. This illustrated the necessity of having

works established under the best conditions, such as prevailed in Australia. The tendency now was to put the works where the raw material was best and and cheapest. In this respect Australia had everything in its favour, but the difficulty was to get capitalists to realise the advantageous conditions which existed here. He had compared analyses of the Lake Superior iron ores with those of Australian ores, and had not found that the former were better than the Australian. He was aware that large quantities of Spanish ores had been introduced into England. He had seen specimens of coal from the Dawson River. It seemed to be a semi-anthracite, but he had not analysed it. It was not quite as good as the Pennsylvanian coal. During 1901, 7,154,000 tons of iron had been smelted with coke, and 2,500,000 tons with anthracite.

By Mr. Groom: The estimation of the Queensland iron ores, so far, were based on surface indications, and could only be that of hard ores. The greater proportion of iron ores were hard on the surface, but softer lower down. He knew of one case in America where the soft iron had not been discovered for fifteen years.

By Mr. Watkins: The Tasmanian ores were hard ores. For this reason he did not attach much importance to an estimation of ore in sight in flat country.

Mr. Kingston: But you attach importance to it when it is practically in sight to the extent of 1,000,000 tons?

Captain Richard: If only a few hundred tons were in sight there might be a very big mine lower down. The work of discovering mines was quite a separate business in America. In Queensland our iron deposits had not even been trenched on.

By Mr. Groom: Although there were some conditions in Australia not so favourable as in America, there were more conditions in this country that were favourable. The conditions at the Blyth River, Tasmania, were very favourable.

Mr. Watkins: You are very distinctly of opinion that iron can be manufactured in Australia at the same cost as in America. Can you explain how, with a difference of about £3 per ton, in favour of Australia, between the the selling cost in America and the price landed in this country, capitalists still require a bonus to induce them to embark in the enterprise?

Captain Richard: He had already explained that in America there were a great many large capitalists—millionaires—who had already vested interests in their own countries, that iron and steel works would improve the undertakings in which their money had been invested, and that they naturally preferred to do what they could to advance the enterprises in which they were personally interested. Similar conditions prevailed in England and in Germany. He would point out, also, that the iron and coal resources of Australia had only been studied quite lately—in Queensland only for a few weeks; and capitalists liked a thing to mature before investing their money. Moreover, pioneers in an industry, who ran special risks, expected to be rewarded for those risks, and for the advantages which they conferred upon a country by their enterprise. Then recent legislation in Australia had had an unsettling effect.

Mr. Watkins: In what respect?

Captain Richard: The Wages Board in Victoria, and legislation of that sort. Capital was always very timid. There were also the risks of mistakes in management. For instance, works might be placed in a wrong position, and other works, more favourably situated, might be erected and cut them out

cent. and 73 per cent. of iron, with a trace of phosphorous in one case and not in the other. That made it almost absolutely pure ore. At Alma Creek shown on the plan and table, there were deposits of titaniferous ore. He read two analyses of the ore:—

	No. 1.	No. 2.
	Per cent.	Per cent.
Water	0·54 ...	0·56
Silver	5·55 ...	10·40
Alumina	12·52 ...	1·70
Iron	55·10 ...	56·27
Manganese	Nil. ...	Nil.
Lime	2·65 ...	2·85
Magnesia	Nil. ...	Not determined.
Phosphorous	Trace. ...	0·025
Titanic Acid	Present but not estimated. ...	Present but not determined.

The second analysis was from a separate deposit. In the Brisbane and Ipswich districts there were also deposits of iron ore, which were shown on the plan and table. Nothing had been done in the way of working them. In the Gladstone district the most important deposit was at Glassford Creek, and this was also shown on the plan. None of the Queensland iron deposits had been worked except for fluxes for the smelting works at Aldershot. The iron ore deposit which he considered the most valuable or the most capable of successful future working was that at Iron Island—that was the one to which he attached the most importance for the purpose of manufacturing iron. Next in order he would take Mount Lucy, on the Chillagoe Railway. In connection with the iron on Iron Island, there was an island close by giving an unlimited supply of limestone. Speaking generally, in all cases where iron had been found in the State, there was abundance of limestone close by except in the Ipswich district. As far as was at present known, the most important deposit of limestone was that at Mortar Island. The deposits at Mount Etna, near Rockhampton, were being worked. He had made some notes regarding the Burrum coal, and had a report by Mr. Rands, a former Government Geologist, and himself. (G.S.Q.P., No. 170, "The Burrum Coal Field.") Howard, the centre of the coal field, was 18 miles north-west of Maryborough by rail. The average percentage of coke shown in the Burrum coal was 66.8 per cent. This was a field likely to be largely drawn upon in the future. It had been worked for the past twenty years, and there was certainly as much coal likely to be taken out in the future as had been got out in the past. The best analysis that had been made for coking purposes showed only three per cent. of ash. As to which was the best coal for smelting purposes, there was a doubt as between the Ipswich and Burrum coal, but at present metallurgists preferred the Burrum. Chromite occurred at Ipswich, but it had not been worked, and and the quantity was not known. At Mount Miller, six miles from Gladstone, there was manganese ore. Manganese was absolutely necessary in the making of steel. The quantity at Mount Miller had been estimated at 160,000 tons. The quality of the ore was better than that ordinarily used for smelting purposes. It was not at present being exported for this purpose, but it was proposed to do so. There was a small amount of manganese near Ipswich, but it had not been examined. He was quite satisfied that Queensland had all the requisites for the satisfactory establishment and maintenance of the iron industry within its borders.

By Mr. Watkins: He was speaking purely from a geological standpoint. Seeing that we had a very pure ore, he did not see, if an attempt to establish the industry failed, that it could be the fault of the ore, provided the fluxes were right. He had heard that after furnaces had been erected and used,

ASTERN COAST

antities	Qualities	Remarks
mated	Not estimated	Both being mined and exported at the present time, output for 1902 valued at £6793
us lodes of Ironstone stible supply	-	—
ustible supply	98% Carb. of Lime	—
000 tons 000 tons	Iron Silica Phosphorus 64·7 2·5 0·065 60 ? nil.	A specimen block assayed a trace of Phosphorus
is aggregating of Coal	(Max) 11% of Ash in Coal (Min) 3·8% of Ash in Coal	Good Steaming Coal, makes firm Coke
imated	Not estimated	Numerous irregular Outcrops
am, Outcrop proved es in length	(Max) Ash in Coke 11% (Min) Ash in Coke 7·7%	Coal yields 84% Coke (Max) 82% Coke (Min)
us 1 mile long ft 6 in thick	Fixed Carbon in Coal 84·6% Ash in Coal 4·8%	Frits when burning, but Coke is not formed
0 tons ustible supply	Iron Silica Phosphorus 67 to 73 ? none to trace	—
iustible supply		200 yards from water's edge
0 tons	Iron Silica Phosphorus 55 to 62 7·3 to 8·3 trace to 0·167	
00 tons	55 to 56 5·5 to 10·4 trace to ·025	Many other Ironstone Outcrops in this District not examined
00 tons	No analysis	Magnetic separation possible
00 tons	Manganese 44% Silica 11·5% Iron 4% Phosphorus trace	Many Deposits not included
l Deposits	No analysis	Many Ironstone Deposits containg from a few hundreds to a few thousand tons each
0.000 tons	11% of Ash in Coal	Contains 9% of moisture a good Steam Coal
0 tons, austible supply	No analysis	Magnetic separation possible
have been worked ating 16 ft of Coal	2% to 7% Ash in Coal	Coke is used at Aldershot and Mt Perry furnaces
rops known	No analysis	Aggregate thickness probably 20 ft associated with Coal Seams
small quantities	Probably too Siliceous	Deposits at Pine Mountain
us Outcrops each or less	50 to 70% Manganese Dioxide	Deposits very irregular
imated	No analysis	Boulders on surface at Pine Mt quality apparently good
annual output 0.000 tons	Coke-hard, 15% Ash from unwashed Coal	Washing would reduce ash in Coke probably to 8%
timated	Not estimated	

even with suitable ores, it had been necessary to pull them down and reconstruct them, but he could not speak of any particular cases. He had not examined our coal with the view of ascertaining whether it was specially suitable as a smelting coal. He believed the coal could produce coke good enough for the purpose, but that was a matter for actual test. He certainly believed that the output of coal would increase, not diminish.

By Mr. Groom: It was only during the sittings of this Commission that he had been specially examining the iron deposits of the State. Before that he had commenced a report on the manganese and iron deposits, but since then he had been solely directing his attention to iron—only during the past month or so. As to the clay ironstone deposits of the Ipswich district, there were ten outcrops within two miles. One seam was two feet six inches thick. Such a seam would contain 11,000 tons of ore per acre. There was no reason why these deposits should not occur throughout the Ipswich coal measures. Even at that thickness they might be worked, but they would not be considered important deposits. The Pine Mountain deposits on the surface were too siliceous, but they might improve with depth.

This closed the evidence taken in Brisbane.

V.—NOTES ON ASBESTOS IN THE ROCKHAMPTON DISTRICT.

For many years asbestos has been known to occur in the serpentine belt which extends in a north-westerly direction from Balnagowan, near Keppel Bay, to Yaamba, Princhester, and Marlborough.

Near Princhester there are some old workings which were opened many years ago to determine the character of the asbestos deposits there. Recently Mr. E. K. Ogg, of Rockhampton, visited the locality, and from the old workings obtained samples of the asbestos for the purpose of making an examination, and to determine their value as a commercial commodity.

The country is serpentine, and the veins of asbestos occur in all sizes up to a foot or more in thickness. The asbestos in the larger veins is coarse in texture, but one sample from a seam about two inches in thickness showed asbestos of a much finer quality. All the samples were much ironstained, and partly decomposed by the action of surface water, the workings not being deep enough to obtain the asbestos unaltered.

Messrs. Hall and Stokes, in a paper read before the Royal Society of Queensland some years ago,* described the asbestos deposits occurring near the junction of Tilpal, Princhester, and Glen Prairie runs, and in their summary regarding the occurrence of asbestos and the propects of establishing an industry in this mineral, states their belief "that, on proper search being made, veins of asbestos of good quality and payable size will be discovered, and that a permanent industry will be the result." They also think that "a wider knowledge of the modes of occurrence and methods of working may lead to search being made in other serpentine areas."

Asbestos, to be valuable, must be pure, clean, strong, fine, and capable of being woven, the latter quality being quite distinct from its degree of fineness, and depending on the somewhat flossy nature of the individual fibres. Many other inferior grades of asbestos are used, however, for manufacturing purposes; but to work asbestos successfully, it appears that the occurrence of the high-class material is indispensible at the outset.

The material obtained recently by Mr. E. K. Ogg, when microscopically examined, shows the fibres to be finer than the best quality of Italian asbestos, but no further comparison could be made, as the sample was too much decomposed; neither, for the same reason, could the structure of the individual fibres be examined to determine their fitness for weaving purposes.

* Proceedings of the Royal Society of Queensland, 1890 to 1893. Vols. VII., VIII., and IX., p. 120.

VI.—NOTES ON THE GEOLOGICAL HISTORY OF KEPPEL BAY.

The occurrence of the phosphate-bearing slate belt referred to in a previous article, and its association with a serpentine belt, discloses some features regarding the geological history of Keppel Bay.

From Balnagowan, on the mainland, to the west of Keppel Bay, a belt of serpentine rock extends north-westerly towards Cawarral and Marlborough, and are parallel with the slate belt trending in the same direction, while on the other side of the serpentine, at Yaamba, there are masses of Devonian limestone which form, with the slates associated with them, a third belt in the same geological series.

The same series appear to have been repeated in the direction of Gladstone to the south-east. The slates of Curtis Island are similar to those north of Balnagowan and at Cawarral, and there are limestones corresponding to those at Yaamba, on the mainland at Raglan opposite Curtis Island, but the serpentine between the limestones of Yaamba and the Cawarral slates are represented between Curtis Island and the mainland by the depression forming the channel and the low country of the "Narrows."

Curtis Island and the mainland to the north of the Fitzroy River once were connected, and the land now forming Curtis Island was a peninsula. At that time Keppel Bay was not in existence, and the river must have had some other outlet to the sea.

The river at that time draining the country fairly agrees with the course of the Fitzroy River of the present day so far as the upper reaches are concerned, but with the slate country of Curtis Island joined up with Cawarral, and Keppel Bay non-existent, the river has trended away to the south-east, and following the line of rocks which least resists its denuding action, has made a course for itself in the serpentine belt, and flowed along the west of what now is Curtis Island in the present channel of the "Narrows."

The country to the west of the peninsula must have been low and swampy, and a vast quantity of sand and mud brought down the river has accumulated there to form a series of sandstones and shales. While this filling-up process was going on the river gradually wore away part of the peninsula, through which a second outlet to the sea was made, thus forming Curtis Island, and with the opening of the new channel the old one by degrees became closed.

Since then the country has been subjected to some alterations in level, and the Mesozoic rocks have been slightly raised and brought with the influence of surface-weathering agencies. The slight elevation produced great changes in the configuration of the country here by converting the low, swampy country into an elevated plain, but the subsequent wearing-down action of both the river and the sea reduced this so much that very little now remains to show it ever existed. Mackenzie Island is a very small remnant of this sandy plain, and other small portions of it are to be found about the "Narrows."

Looking backward in the history of these events, we see one period—probably in early Tertiary times—when Keppel Bay and all its islands was an area of dry land connecting up Curtis Island with the mainland at Cawarral and forming a peninsula. Mackenzie Island was then part of a sandy plain, and extended round all points of the compass; extended easterly towards the peninsula, northerly towards Balnagowan, westerly along the north and south banks of the Fitzroy River, and southerly to Port Alma and the country about the "Narrows."

The Fitzroy River, flowing easterly, formed a channel through the plain of Mackenzie Island sandstones, and when it reached the slates of Curtis Peninsula trended south-easterly along the course of the Narrows to enter the sea at Port Curtis.

VII.—ORIENTAL RUBIES IN THE TATE RIVER, NEAR CHILLAGOE.

While travelling across from Cairns to Croydon, inquiries were made in passing through the tin districts concerning the occurrence of rubies with stream tin. A number of red stones in the possession of the miners were examined, and although the locality they came from was not visited, some of them were found to be Oriental rubies. Zircons are plentiful in the tin "wash," and garnets of exactly the same colour as the rubies have been found with the latter stones at the "Rocky" Tate River. Two rubies of commercial value were obtained from one of the mines—one being about a carat in weight, the other a carat and a-half, both of a bright clear colour. The garnets matched the rubies perfectly in colour when cut, although readily distinguished in the rough state by an absence of pleochroism and by their inferior hardness.

It is impossible to surmise what stones of value are thrown away by the alluvial tin-miner, but as the rubies obtained by me were only saved with other stones which the miners consider curiosities, such as zircons and garnets, probably good stones, regarded as valueless, are washed away in the tailings.

It would be advisable for miners to always save bright-coloured, transparent stones, and obtain some estimate of their value from the Geological Survey Office, from which also any other desired information on the subject can be given.

VIII.—ON THE OCCURRENCE OF THE GENUS HALYSITES IN THE PALÆOZOIC ROCKS OF QUEENSLAND, AND ITS GEOLOGICAL SIGNIFICANCE.

By R. ETHERIDGE Junr., Curator of Australian Museum, Sydney.

In the "Annual Progress Report of the Geological Survey [of Queensland] for the year 1900,"* Mr. B. Dunstan announced the discovery of the Silurian genus of corals known as *Halysites*—more popularly called the "Chain Coral"—in the limestones south-west of Mungana, in the Chillagoe District. This is an exceedingly interesting discovery in Queensland Palæontology, and one of high geological importance.

The limestones were at one time regarded as Permo-Carboniferous in age;† subsequently Dr. R. L. Jack‡ referred them to the Devonian, and, lastly, Mr. S. B. J. Skertchly§ again returned to a Carboniferous age, placing the limestones towards the close of that epoch.

The specimens submitted to me are preserved in a blue-black, or almost black limestone, and from their siliceous composition the corals weather out on the surfaces. The colonies are of limited extent, and of an erect and shrub-like growth apparently. The fenestrules are not individually of large extent, the larger measuring 4 × 4 mm. to 4 × 6 mm., and in outline vary from rectangular to oblong, and without such a marked tendency to that polygonal form seen in several of the New South Wales species of the genus; neither does one diameter greatly exceed the other. It follows that the angles of junction of the vertical laminæ, or corallite chains, are not so variable, and often approximate more to a right angle. The fenestrule walls are strong, but, in consequence of the extensive secondary alteration the tissues have undergone, the epitheca is very indistinctly and feebly preserved.

The actual length of the corallites is unknown, but so far as can be ascertained from the mode of preservation, they did not attain any great degree of height. The corallites are all "normal," *i.e.*, autopores only appear to be present; these have a diameter, in the direction of the chain, of from one millimetre to one and a quarter millimetres. The corallite chains are short, only slightly farcimentiform, the number of autopores in a given chain being only from two to four, but the average three. The autopores abut closely against one another, the inter-autoporal walls being thickened, and leaving no space for interstitial tubes or mesopores, of which not a single trace has been observed in any of the sections prepared.

The structure of these thickened walls, whether inter-autoporal or fenestrule-bounding are, when viewed in microscopic sections, perfectly homogeneous.

* Dunstan—Geol. Survey Report, No. 159, 1901, p. 21.
† Jack and Etheridge—Geol. Pal. Queensland, &c., 1892, pp. 609 and 739.
‡ *Fide* Dunstan, *loc. cit.*
§ Skertchly—Proc. R. Soc. Queensland, 1899, xiv., p. xxiii.

The corallites termed gonopores by me, placed at the angles of junction of the corallite chains, are generally developed, but not invariably so; when absent the autopores at the angles abut closely against one another; when developed they are either round or obscurely polygonal.

The tabulæ are complete, more or less horizontal, and never vesicular; but, owing to an occasional slight obliquity, cut edges are now and then seen in transverse sections of the autopores. The first point that strikes one on examining a longitudinal section is the extreme regularity and delicacy of the tabulæ, presenting precisely the appearance of the rungs in a ladder. Some are one millimetre apart, others three-quarters of a millimetre, and they are either opposite in contiguous corallites or slightly alternating. The visceral chambers are either square or transversely oblong.

The absence of mesopores is also more forcibly brought home to the observer on examining a longitudinal section, for wherever the latter traverses the vertical plane of a corallite chain, the normal tubes are all seen in close contact with one another.

Septal spines are present, but feebly developed, and are arranged in one or two, and possibly three cycles in each visceral chamber.

If the absence of mesopores is truly a structural and not a superinduced character, one brought about by secondary changes in the coral's tissues, the Chillagoe *Halysites* is quite distinct from any of the forms discovered of late in New South Wales. True it is that mesopores in more than one of the latter are unstable in their development, but in none of them are these corallites totally wanting. There is also a marked absence of mesopores in a *Halysites* I described* from the Gordon River Limestone, in Tasmania, and with this a general similarity of other characters, so much so, indeed, that I shall not be surprised to find the two corals are identical.

For the Chillagoe *Halysites* I propose a specific name in allusion to the locality, with the following abbreviated characters:—

HALYSITES CHILLAGOENSIS, *sp. nov.*

Sp. Char.—Corallum forming shrub-like colonies of small size. Fenestrules oblong or irregularly quadrangular, the diameters more or less equal, and the angles approximating to right angles; sizes 4×4 mm., 4×6 mm., &c.; walls strong, but much altered by secondary silicification; margins straight, or very slightly undulate. Corallite chains short, only in a slight degree farcimentiform; autopores oval, two to four in a chain, about one to one and a-quarter millimetres in longest diameter; septa feebly developed in from one to three cycles; pseudo-columella not observed; tabulæ very regular, complete, horizontal, from three-quarters of to one millimetre apart, opposite or subopposite in contiguous tubes; visceral chambers square to transversely-oblong. Mesopores absent, the inter-autoporal walls solid, and trenchant at the surface. Gonopores generally but not invariably developed, when present round, or obscurely polygonal; tabulæ about half a millimetre apart; visceral chambers square.

* Etheridge—Proc. R. Soc. Tas. for 1898-99 (1900), p. 81.

Halysites chillagoensis is a form of high morphological importance, for it proves what has been elsewhere foreshadowed (in the New South Wales species), that gemmation may go on direct from autopore to autopore, without the intervention of a mesopore.

The presence of *Halysites* in the Chillagoe Limestones, lends colour to a belief in the existence of Silurian rocks in Northern Queensland. We already know of the presence in the south-west portion of the State, along the South Australian border, about 23° S. Lat., of rocks supposed to represent some part of the Ordovician Series,† and it is not, therefore, unreasonable to anticipate that throughout the great expanse of "slates, schists, greywackes, quartzites, &c., of undetermined age," shown on the Geological Map of 1892, over Central Queensland, and extending even into Cape York Peninsula, some areas at least may prove to be of Silurian age.

I believe I am correct in stating that *Halysites* is unknown in rocks of Devonian age. If this be so, we are face to face with one of two conclusions—either the Chillagoe Limestones containing this coral are of Silurian age, or, the beds in question must be regarded as Devonian, accompanied by an extended range in time for the coral. I favour the former conclusion.

Halysites extends throughout the Ordovician Series into the Upper Silurian, as high as the Lower Ludlow, but a sufficiently extended examination of the Chillagoe corals has not yet been made to warrant the expression of a decisive opinion of their age in particular.

† Jack—Proc. R. Soc. Queensland, 1895-96, xi., p. 73; and Note on the Discovery of Organic Remains in the Cairns Range, Western Queensland.—*Ibid.*, 1897, xii., p. 47.

By Authority: George Arthur Vaughan, Government Printer, William street, Brisbane.

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NOTES

ON

TIN, COPPER, AND SILVER MINING

IN THE

STANTHORPE DISTRICT

(WITH 13 PLATES).

By LIONEL C. BALL, B.E.,
ASSISTANT GOVERNMENT GEOLOGIST.

BRISBANE:
BY AUTHORITY: GEORGE ARTHUR VAUGHAN, GOVERNMENT PRINTER, WILLIAM STREET.

1904.

LETTER OF TRANSMITTAL.

Queensland Geological Survey Office,
Brisbane, 13th March, 1904.

SIR,—I have the honour to forward for publication Mr. Ball's "Notes on Tin, Copper, and Silver Mining in the Stanthorpe District."

A short visit of inspection was made by Mr. Ball at the end of 1903, and the notes he has compiled bring up to date all the information concerning mining developments in that part of the State.

The notes embrace—

(1) A general review of tin-mining at Stanthorpe, including a description of ground-sluicing, dredging, and lode-tin mining;

(2) An account of recent developements at the Sundown Copper and Tin Mines, at the Silver Queen Mine, Severn River, and at the Pikedale Silver Mines; and

(3) A description of the silver and copper mines in the neighbourhood of Texas.

I have, &c.,
B. DUNSTAN,
Acting Government Geologist.

To the Under Secretary for Mines.

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(WITH THIRTEEN PLATES.)

I.—Notes on Tin Mining in the Stanthorpe District.

The tin-mining industry in the Stanthorpe district has always depended on the alluvial, none of the lodes hitherto discovered having proved either rich enough or permanent enough for exploitation. Very little can be added to what Mr. Skertchley has said in his report* on the district with regard to the ordinary primitive methods of saving the tin; but since that report was written dredging has been introduced, and should prove in numerous cases a pronounced success. It is my opinion, and that of experienced tin-mining engineers from other States, that there is a bright future before Stanthorpe, but that capital and modern appliances for the economical treatment of large quantities of material are necessary in order that the tin ore still in the "wash" may be saved.

I.—PAN-WASHING AND CRADLING.

Pan-washing and cradling have now practically gone out of use in favour of box and ground sluicing. Just at the time of my visit (November-December) there were very few men on the alluvial, even the ordinary average having been reduced owing to the swollen state of the creeks, due to late rains. There are believed to be about 100 alluvial men in the district, but I think that greatly in excess of the number. Most of the work done by these men is working over the old alluvial, sometimes for the third time; but some of the creek beds are found to be worth attending to after every flood.

II.—GROUND SLUICING.

(a) SUGARLOAF CREEK.

Most of the tinstone now being got is from the Sugarloaf Creek district, and the greater part of that is brought in by Chinese. Part of the old Brisbane claim has been subleased to one of them, who employs ten men, and has done a large amount of work—turning over old tailings chiefly. A large stream of water is brought in a race from a point on Sugarloaf Creek, 2½ miles distant, and by its aid the old tailings, to a depth of 10 feet, are sluiced down. On the bottom is a bed of "cement," 2 to 4 feet thick, which the Chinamen do not attempt to penetrate, though it is believed that wash exists underneath it. The great difficulty in ground sluicing is the liability to failure of the water supply, droughts, even in this district, causing stoppages for several months in the year.

No information could be obtained from the gentleman in charge, because of the want of an interpreter. It is considered that five sluicers should put

* G.S.Q. Publication, No. 120. Geology of country round Stanthorpe and Warwick, with especial reference to the Tin and Gold Fields and the Silver Deposits. By Sydney B. J. Skertchley, late Assistant Government Geologist. Brisbane: By Authority. 1898.

through 20 cubic yards a day, so that ground carrying 4 lb. of tinstone per yard would yield a profit of 9s. 9d. per man, with tinstone at 68s. per cwt., the present (December) local price. The ground worked by the Chinamen contains probably less than 2 lb. per yard.

(*b*) Severn River.

Locality.—During the last few months Prospecting Areas 47 and 48 have been pegged out on the Severn River, 6 miles west of Ballandean Railway Station, and 14 miles south-west of Stanthorpe. P. A. 48 includes a flat-topped ridge, 10 chains wide, running parallel to and on the left side of the river, and rising 60 feet above it. P. A. 47 is in the gully to the west of the ridge. In addition to the above, the company holds a 20-acre water area, which takes in a waterhole 20 feet deep, 1 chain wide, and 10 chains long, adjacent to P. A. 48.

Geology.—The occurrence of rich residual surface tinstone here is mentioned by Mr. Skertchley*, and is shown on his map, so that this is not a new discovery, but simply an attempt to work ground not hitherto considered payable.

The country rock on the claims consists of granite and greisen (with north-north-west master-joints), exposed by denudation of the overlying slates, but as yet very little eroded themselves—that is to say, the rock exposed is the uppermost portion of the intrusive mass. A large part of the granite has been greisenised, owing, as Mr. Skertchley explains, to the spreading out at the base of the slates of the "greisenising liquids" (or, more properly, the pneumatolitic solutions) from the granite. In one place on P. A. 48 the greisen forms a large outcrop, and several trenches have been cut on it. A shaft was sunk 30 feet in it, coarse tin being found in places, with a little wolfram and molybdenite, and also a few patches of mispickel. A number of trenches have been cut, and some of the heaps beside them yield as much as ¼ oz. of coarse tinstone (crystals up to ½ inch in diameter) to the dish. Two tons of tin are reported to have been obtained from this locality—apparently from rich but scattered bunches.

Mr. Baker, who is in charge of operations, expects that 30 acres of the ground will average from 2 to 4 feet of soil, yielding 4 lb. of tinstone to the yard. The whole thing depends on the testing of the ground, which requires a large number of holes.

Plant.—Water will be raised from the waterhole to the highest point on the ground by a 16,000-gallon Knowles duplex pump, which has been erected on a rocky platform 10 feet above the ordinary level of the water, but below flood level, and is to be served with steam from a Pennsylvania marine-type multitubular 12-horsepower boiler, situated 25 feet above the water and clear of floods. The water will be forced from the pump through 6-inch flanged galvanised iron Zollner pipes, which are made in 18-feet lengths, weighing 50 lb. each, and specially suitable for transport to such inaccessible places as this. They have been tested to 200 lb. pressure, so that it will be possible, if future operations show it to be advisable, to undertake hydraluicing with the present plant.

The method of working will consist in having five or six main races radiating from the topmost point; into them the soil from the intervening ground will be sluiced, the soil being washed down into the river and the tinstone left behind.

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* *Op. cit.*, p. 48.

Plate 1.

Photo., L.C.B.

WYLIE CREEK DREDGER, N.S.W.

Showing Revolving Trommel, Sluice Boxes, and Long Tom.

Great trouble was experienced in getting the machinery on to the ground, owing to the road from the railway reaching only to Ballandean head station; beyond this a track had to be cut across a precipitous range, which might have been escaped, and the river bed followed, but for the floods just then prevalent.

III.—DREDGERS.

There are two dredges in the Stanthorpe district, in Queensland, and one in the continuation of the same country in New South Wales. Owing to the late drought they were able to do nothing till the middle of last year. That in New South Wales is now on a dividend-paying basis, and a description of it is given below for comparison with the Queensland dredgers, one of which is now in a fair way to successfully work its ground. I have to acknowledge the great assistance rendered me in each case by the manager.

(*a*) New Wylie Creek Dredging Company (Mr. Bryce, manager).

The New Wylie Creek Dredging Company has a nominal capital of £31,000, of which £29,000 has been allotted in 10s. shares. Three leases, amounting to nearly 200 acres, are held from the Crown.

Locality.—Wylie Creek is a tributary of Harding Creek, which flows into the Clarence River.

The present dredger is $3\frac{1}{2}$ miles below Wilson's Downfall, on the Stanthorpe-Tenterfield road, $5\frac{1}{2}$ miles from the Queensland border, and 15 miles by road from Stanthorpe. It lies on a large 27-acre flat (practically all worked over by the earlier miners), near the lower end of the leases. The creek for miles below this has been worked by miners, but it is not considered dredgable. On account of the success of the first dredger a proposal is now being considered to erect another about half a mile up stream, where the ground, being too deep for the miners, is expected to be richer than the old tailings.

Ground.—According to the borings, which were made in rows 10 chains apart, the ground should carry 2 lb. of tinstone per yard, but the dredger during the last half-year saved only $\frac{3}{4}$ lb. per yard, and as the manager believes he saves 75 per cent. of the tin ore put through the dredger, the total in the wash cannot be more than 1 lb. Just at present slightly better results are being obtained, but it is probable that the dredger will be turned, and its tailings put through as a test. The ground which thus far has given best results is what was too poor for the miners, and consequently untouched by them.

The average depth of the ground is 14 or 15 feet over the whole of the dredgable portion, and the average width is 7 to 8 chains. The bottom is a soft decomposed granite. Little trouble is experienced with boulders, only one bank of them having yet been encountered; and, just at present (November), the dredger is passing through fine drift sand.

Dredger.—The new Wylie Creek dredger was finished by the end of 1901, but, owing to the drought, a start could not be made till March, 1903, and then the water to float it had to be pumped into the paddock for a month or two. Till June only one shift of men (working eight hours a day) was employed, in August a second was put on, and now three shifts are working.

The dredger is of the ladder-bucket form, and cost between £6,000 and £7,000. The pontoon is 40 feet in length by 20 feet across (dimensions approximate), and owing to its comparative shortness, the heavy sluice boxes at the stern cause that end to sink a couple of feet deeper than the bows, even

though numerous large half-ton boulders dredged up are used as ballast. The machinery (including the buckets, winches, and pumps) was supplied by the Clyde Engineering Works, and is all driven by a 12-horsepower compound engine.

There are 27 buckets, of 4 cubic feet capacity, provided with tire-steel lips, and spaced 4-feet centres, and the ladder allows dredging to a depth of 20 feet. The material raised by the buckets should be thrown on to a manganese steel "dropshoot," but while in shallow ground the buckets do not pass within 6 inches of the shoot, and then much of the wash (often half a bucket) misses the shoot and falls down the well into the paddock again. This represents a serious waste, so that an easily adjustable shoot is a pressing want. Mr. Bryce has computed that the buckets are capable of raising 8,000 or 9,000 tons of material a week, though, since August, they have been raising only 5,000 to 6,000 tons, owing to defects in the sluice boxes.

A stream of water, raised by a 10-inch centrifugal pump, sweeps the wash down the shoot into a revolving trommel or screen, 4 feet in diameter and 8 feet 6 inches long, punched with $\frac{3}{8}$ and $\frac{1}{2}$-inch holes. All the tin ore here being very fine, $\frac{3}{16}$-inch holes would, in Mr. Bryce's opinion, be quite large enough. If the material were put through two screens, preferably concentric, there would be far less material to go over the tables, and a greater amount of wash could be put through in a given time, with a correspondingly greater chance of saving the tin.

From the trommel the coarse material discharges onto a shoot and is washed out astern, while the finer wash, carrying the tinstone, passes through the screen onto side shoots (one of which, it is interesting to note, owing to the motion of the trommel, receives nearly double the quantity of the other), and thence is swept on to two sluice boxes or tables running out beyond the stern. These boxes are 4 feet wide and 40 feet long, and are built of iron. The sand is kept 6 inches deep in them, and under 3 inches of water. Most of the tinstone is saved within 5 feet of the top of the tables beyond the trommel shoots. One man with a shovel is stationed there, and keeps the sand stirred up, while, at present, for experimental purposes, another man shovels back the sand in the lower part of the sluices. Owing to the tables not being able to discharge the "wash" from the trommels quickly enough the buckets have to be stopped every now and then; but for this there are two available remedies—namely, to widen the sluice boxes (Mr. Bryce would have them double their present width), or else to use a double screen, as proposed above, so that less of the material raised would have to pass over the tables.

The concentrates from the tables average 7 cwt. to the yard, and are sluiced off in a long tom (10 feet long and 18 inches wide), by two men on the dredger, and then taken ashore to the Willoughby machine shed for final cleaning.

Normally five men are employed on the dredger on each shift, an engineer (who is also winchman and engine-driver), and two men on each sluice box. When the photographs were taken there were two more men on the dredger attending to the long tom. In addition to the above two men are employed in the day shift loading wood, which it may be mentioned costs 8s. a cord here.

Cleaning.—The black and white sand (including a few small topazes), is separated from the ore in a Willoughby machine, which acts on the principle of an upward current separator, and is the invention of a Stanthorpe man. It consists (*see* Plate 3) of an outer tank, with hand pumps and pressure box (if a stream of running water is not available), and a separating box, with false

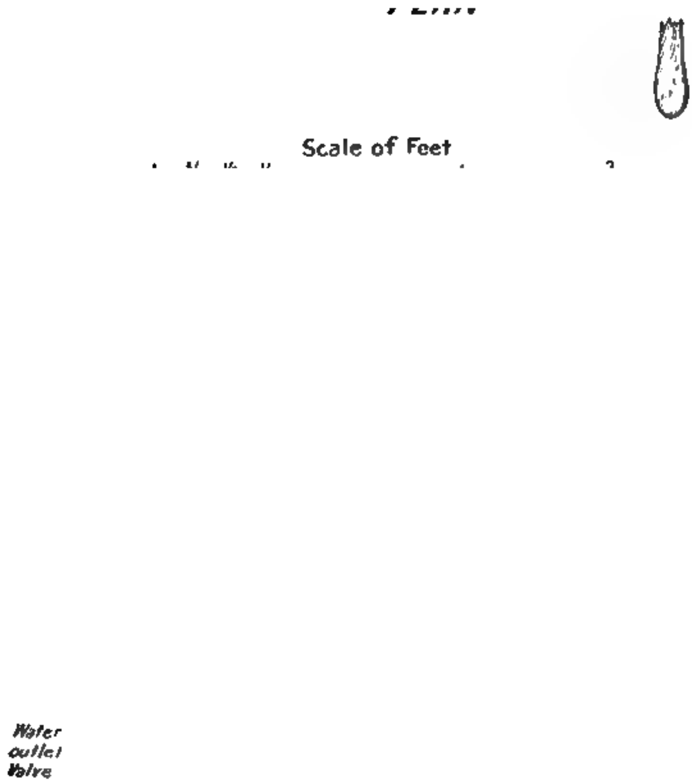
Plate 2.

Photo., L.C.B. Fig. 1—WYLIE CREEK DREDGER, STERN VIEW.

Looking Up the Sluice Boxes.

Photo., L.C.B. Fig. 2—WYLIE CREEK DREDGER, BOWS.

Showing Dredger Cutting into Bank of Old Tailings.



ELEVATION

DIAGRAMATIC SKETCH OF WILLOUGHBY MACHINE.

bottom (a copper plate with $\frac{1}{32}$-inch perforations). The crude ore, about 4 cwt., is placed in this box to a depth of 6 inches, and a stream of water under a head of from 1 to 3 feet is allowed to rise through it, causing the lighter impurities to ascend to the top, where they are scraped off. The operation is repeated about five times, and then the cleaned tin ore (cassiterite) is dried on an iron plate (10 feet by 5 feet in area), heated over a grate. The tinstone, as bagged for shipment, averages 76 per cent. of tin (varying from 75.3 to 76.4 per cent.).

Returns.—On the dredger's trial run 30 cwt. of tin ore was obtained after 255 hours from 10,000 tons of wash, which, however, according to the boring results, should have yielded 10 tons. About 40 tons of ore have thus far (November) been obtained, together with 4 tons of black sand. For the week ending 21st November, 50 cwt. of tinstone was obtained from 5,500 tons of wash on a 114 hours' run. Of this amount between 15 and 20 cwt. probably paid expenses, leaving a very fair profit.

The first dividend of 3d. was declared in October, and was followed by a second in November, and a third in December.

The table below has been compiled from weekly returns published in *The Border Post*:—

Month.	Yield of the Ore.	Hours Working.	Dividends.
	Tons cwt.		s. d.
December, 1903	8 16·5	397	0 3
November	9 5	436	0 3
October (two weeks)	3 9	306½	...
September	8 10	371	0 3

The best result was thus about ½ cwt. of tin ore per hour. The Sydney quotation for tin at the end of 1903 was 21s. 6d. per unit.

Conclusion.—The Wylie Creek dredger can now be considered a success, the long interval of inaction between erection and actual working being entirely due to the drought. Mr. Bryce attributes his success to the use of the revolving screen in the first place, and to the employment of a sufficient number of men in the second. The location of the dredger is on a large flat, and the fairly uniform and fine nature of the material treated are prime factors, though the separation by the screen of the coarser stuff has undoubtedly had a very beneficial effect on the saving of the tin and on the total amount of material put through.

It is understood that lately the water has become scarce, and it will probably be necessary to construct a dam above the dredgers for a reservoir.

(b) Stanthorpe Proprietary Tin Dredging Company

(Mr. Martyn, manager).

Locality.—This is a Sydney company, of 25,000 shares, of which the 10,000 are paid up to £1. Leases up to a quarter of a mile in width have been secured from private owners for a distance of 2½ or 3 miles along Quart-pot Creek. These are on the bend round the old Brisbane claim, which has been considered one of the largest and richest alluvial areas in the district. The dredger lies at the south-western and lower end of the leases—3½ miles in a direct line a little south of east of Stanthorpe, the distance by road being 5 miles.

Ground.—Owing to insufficient prospecting by borings, the dredger was erected in one of the worst possible positions, being cut off from the creek by a bar of granite, and from the higher wash by a bar of "cement" a chain wide, running diagonally up the creek for a quarter of a mile. The dredger has done little more during the last six months than cut its way to a depth of 11 feet through this bar.

This "cement" occurs in flat layers from a few inches to several feet thick, and from a few square yards to several acres in area, at various depths beneath the surface. Though generally poor itself in tin ore, there is often tinstone both above and below it. It is composed of granite detritus, chiefly grains of quartz, in a felspathic matrix, and in my opinion it owes its origin to the action of carbonic acid solutions on the felspars. These solutions may have been derived from decaying vegetation above, and have sunk into the rotten granite, causing a complete decomposition of the felspar, the potash going off in solution, while silicate of alumina was precipitated as a cement. The occurrence of occasional rounded pebbles in it might be explained by their having sunk into the mass before the secondary alteration and solidification took place. This rock has been found in most of the workings about Stanthorpe, and will prove one of the most serious obstacles to bucket dredging there.

It is believed that the wash has been mined under the "cement," and it is therefore not intended to drop the buckets to the bottom till the old ground beyond the "bar" is reached. At the end of November softer cement was entered, and the amount of tinstone saved immediately began to increase.

While going through the harder cement blasting had to be done practically all along the face. The holes were placed 6 feet centres in rows 4 feet apart, and 2½ lb. rack-a-rock was fired in each, 5 feet below the water-line. The amount of the hard cement raised was only 2 cubic yards an hour, but in the softer 40 yards is now being raised, and it is expected that the dredger will manage 60 yards in the old ground, which extends (with soft bottom) for a chain to the east of the bar at the southern end, but widens towards the north.

The ground is understood to have been sampled, but for the directors' private information only, so that statistics of the contents are not available. It is said that in the original washdirt the tinstone was mixed with 10 per cent. of black sand. Now, in the old workings there are generally about equal proportions of the two minerals, though, owing to the Chinamen's sluicing, the proportion of black sand to tinstone is often as 5 to 1.

The Dredger.—The dredger was completed in June, 1902, but remained idle for twelve months, owing to the drought. It cost approximately £11,000.

The boiler is a 25-horsepower multitubular semi-loco. with enlarged grate; firewood now costs 11s. per cord, but in the late wet weather it rose to 16s. All the machinery is driven by a 20 nominal horsepower (140 indicated horsepower) condensing engine, with feed-water heater. There are 34 chrome-steel-lipped buckets of 4½ cubic feet capacity, the ladder allowing dredging to 25 feet depth. (*See* Plate 5.) Attached to one of the buckets is a pair of grabhooks for raising logs and boulders.

The material from the buckets is tipped on to a steel shoot, but, owing to the unavoidable clearance space between the buckets and the shoot, clayey and sticky material very often misses the shoot, and falling down the well fouls the bottom of the paddock. A second shoot was therefore installed below the main one, and a trial was made to see if it would pay to treat it in a long tom, but owing to the poverty of the ground ("cement") at the time, the experiment was a failure from a financial point of view. The material is

Plate 4.

Photo., L.C.B.

STANTHORPE PROPRIETARY DREDGER.

Plate 5.

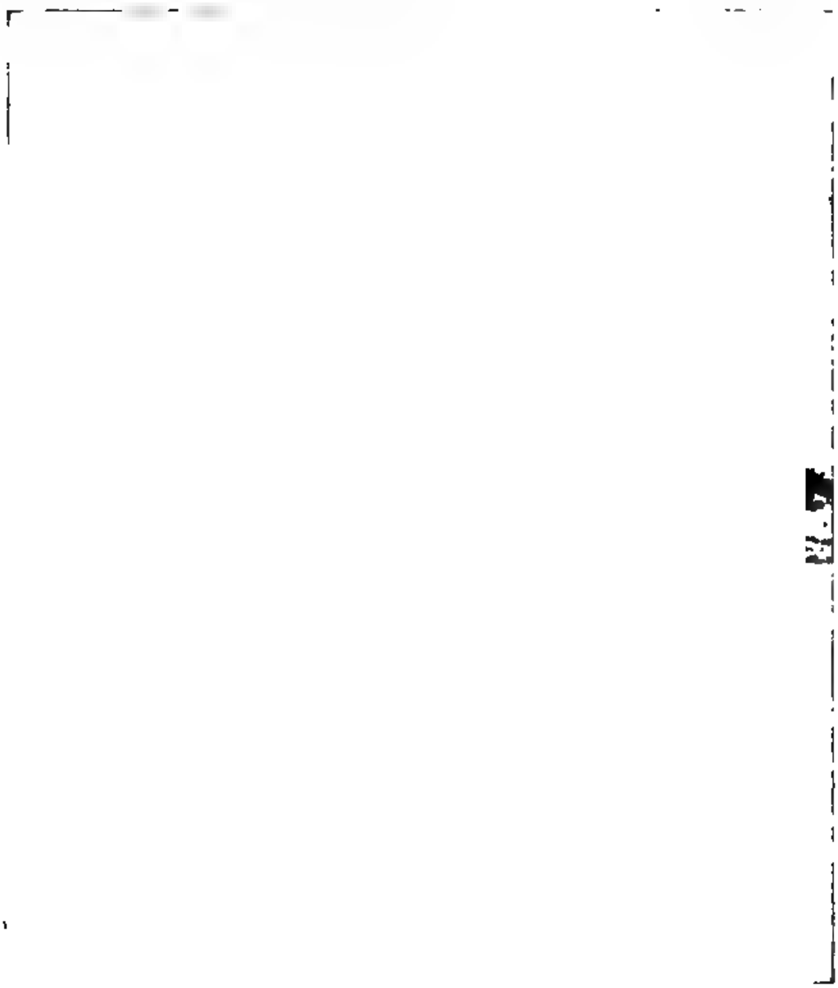


Photo., L.C.B. STANTHORPE PROPRIETARY DREDGER, BOWS.

SHOWING METHOD OF SUSPENDING "LADDER."

Plate 6.

Photo., L.C.B.

STANTHORPE PROPRIETARY DREDGER, STERN.

Showing Upper Works and Launders for Coarse and Fine Tailings.

Plate 7.

Photo., A. P. Currie. STIRRING RAKES, STANTHORPE PROPRIETARY DREDGER.

now, therefore, simply run out behind the dredger. From the upper shoot, where it is proposed to have a jet of water, the material is washed by a 12-inch stream of water from a 9,000-gallon pump over a grizzley with bars ⅜ inch apart. This serves instead of a revolving trommel, the finer stanniferous wash falling through on to a central distributing table, 25 feet by 8 feet in area, while the coarser material, including many unbroken lumps of clayey wash, is swept down a launder and banked up astern of the dredger, preventing the fines from the sluice boxes, deposited beyond, settling under the dredger. (*See* Plate 6.)

From the distributing box the tin-bearing sands are washed on to five lateral tables (12 feet long, 5 feet wide, and falling ½ inch in a foot) on each side. The sand is kept stirred in each of the tables by seven rakes, made of ¼-inch iron rods set 1½ inches apart in a wooden bar attached to endless chains worked on toothed wheels. (*See* Plate 7.) Each lateral table is divided longitudinally into four compartments to prevent "guttering." The tendency is for most of the sand to enter the first tables and the water the last, and, therefore, launders with a valve for each compartment have been provided, so that water can be added when necessary. Most of the tinstone saved is within 5 or 6 feet of the top of the tables.

Only one shift has thus far been employed, consisting ordinarily of three men (engineman, fireman, and grizzley man), and two lads (one loading timber—enough for three shifts in one day—and the other on the long tom in connection with the lower drop shoot).

The total expenses, working three shifts and allowing for wear and tear of machinery, for firewood, and salaries, Mr. Martyn has calculated will be £170 per month. About ½ ton of tin ore is now being saved a week (for 30 hours' work), so that, though not in the main ground, the dredge should be just paying expenses. On 3rd December 2 cwt. of cleaned tinstone was saved as the result of five hours' work.

Another of the difficulties here will be in connection with the water supply, but it is hoped that by pumping water from a hole in Quart-pot Creek into the Chinaman's race it will be possible for both ground sluicing and dredging to go on throughout the year. In fact, already a small quantity of water, for renewing that in the paddock, is being derived from the race.

Much of the ground to be dredged will be a flat terrace, slightly above the creek, so that the conditions are not so favourable as at Wylie Creek, for it will often be necessary to build a puddle wall at the lower end of the paddock. The immense boulders of undecomposed granite scattered through the wash, and the beds of hard "cement" so characteristic of the Stanthorpe district, will cause further trouble.

(*c*) Broadwater Proprietary Tin Dredging Company.

Locality.—This company has leases for about 2 miles along Broadwater Creek, 6 miles north of Stanthorpe (8½ miles by road). The prospecting bores, sixty in number, put down by the former holders, gave an average of 5 lb. of tinstone per cubic yard, to a depth of 9 feet over a width of 9 chains, for a distance of 110 chains; and an average of 3 lb. per yard, with 6 feet depth and 7 chains width, for a distance of 40 chains. They found the granite bottom soft, and reported finding not a single large boulder.*

Dredger.—The dredger was completed in 1901, and was worked at a loss for several weeks. During the floods in the latter part of 1903, the pontoon became partly submerged, and remained so till February of this year.

* Annual Report of William H. Rands, Government Geologist, for the year 1900.

The pontoon is 90 feet long by 30 feet broad, and 7 feet deep. One of Marshall's semi-loco. tubular "Dredger" boilers supplies steam for the winch engine (8-inch diameter and 6-inch stroke), for the main engines (double expansion 12-inch stroke, and 12 and 6 inch diameter) which are provided with feed water-heater and condenser, for the small Crompton engine working the electric light dynamo, and for the various pumps. Firewood is expected to cost not more than 8s. a cord.

The buckets, thirty in number, have a capacity of $4\frac{1}{2}$ cubic feet, and are capable of raising 2 cubic yards of wash a minute.

The wash from the buckets was tipped on to a steel plate 6 feet long and 4 feet wide, and thence washed down by water from a four-valved tank onto a wooden sluice box, extending out to the stern. This is 7 feet wide at the top end, and 6 feet at the bottom, and has a length of 25 feet, with a fall of about 6 inches. A 4-inch slit near the bottom of the sluice allowed the heavy fines to drop through into a three-compartmented sluice (10 feet long, and falling 3 feet), running back towards the bows, and discharging into a pointed box, where upward current separation of the tinstone and sand was attempted. The coarser material in the sluice box was carried 15 feet beyond the stern in a launder 7 feet wide.

Ground.—The face worked was about 2 chains wide, and the dredger probably worked forward about 3 chains, but no tin seems to have been saved. The greater part of the wash turned over was fine sand with pebbles of crystallised (chiefly smoky) quartz, and it is considered that the old tailings average at least $1\frac{1}{4}$ lb. of tinstone per cubic yard. A little gold is sometimes found with the tin, and a prospector living in the vicinity showed me three small diamonds, a very light-coloured beryl (a crystal $\frac{1}{2}$ inch long), and several topazes. The largest of the diamonds, a white, slightly pitted and encrusted hexakis-octahedron, was $\frac{1}{2}$ carat in weight; the second, $\frac{1}{4}$ carat in weight, slightly off colour, had a roughly cubical form, but was covered with very numerous facets, and the third was a yellow fragment, $\frac{1}{8}$ of a carat in weight. The wash is reported to have been from 10 to 14 feet deep, but the tin is known to have run in very narrow shoots, as the old workings show.

The average depth of dredgable ground over the whole property is taken as 9 feet. There is a clear width of 7 or 8 chains between the rocks, where the dredger is now, but some 5 chains below the dredger the rocks on opposite sides are only 3 or 4 chains apart, and a few chains above the dredger is a granite bar, above which the dredgable portion averages 5 chains in width, and extends for about 30 chains. For 40 chains below the flat where the dredger is now, the ground is undredgable, or else very poor, except for small patches a few chains broad and long, but further on is a 15-acre triangular area, 6 to 9 feet deep, which has been well turned over by the miner.

Working.—In order to work the ground on these leases dams will have to be constructed for a water supply, and the dredger will have to be floated over the rocky portions by building weirs. Luckily, the rocky part below the dredger has a very slight fall (25 feet in a mile), and only two weirs will be necessary there. It is difficult to understand why the dredger was erected in its present position—namely, in the centre of the lease— for it will be necessary now to work towards one end, and then to get at the ground at the opposite end the dredger will have either to be dismantled and re-erected, or else it will have to dredge its way back through its own tailings.

Mr. Martyn (the superintendent of the Stanthorpe Proprietary dredger) has lately taken charge of this dredger. He has pumped out the pontoon,

refloated it, and proposes to dismantle the whole of the tin-saving appliances, replacing them by an entirely different design. The cause of the failure of this dredger is put down entirely to the inefficiency of the tin-saving appliances.

(*d*) Sheehan's.

Mr. Rands, in his annual report for 1900, besides referring to the building of the Broadwater and Brisbane dredgers, mentions Sheehan's property on Broadwater, 4 miles slightly north of west of Stanthorpe. "Large amount of water. . . a series of waterholes. . . and only the shallow ground worked. . . Dredgable for 8 or 10 chains width and 14 to 16 feet depth. . . Conditions satisfactory, but no boreholes."

I heard when leaving Stanthorpe that a suction dredge had been brought from New South Wales and tried on Sheehan's, but that it had been a failure, had been dismantled, and was being removed to New South Wales again.

Mr. Sheehan has since forwarded me the following particulars:—70-horse-power multitubular loco-type steam boiler; No. 4 Knowles's duplex steam feed-pump; pair Morris Machine Company's vertical engines, direct coupled to a No. 8 sand pump, 8-inch delivery and suction, driven at about 300 revolutions per minute; capacity 30 yards of solids per hour. About 1,100 yards were taken out of the paddock, under great difficulties, owing to lack of water. Yield 1½ tons of tin ore—a little over 3 lb. to the yard. It was dismantled because capital not sufficient to construct a dam for conserving water, to purchase a break-down pump, and to obtain a proper set of boxes. Both washdirt and overburden are chiefly coarse sand and gravel.

(*e*) Prospecting on Four-mile Creek.

Locality.—Four-mile Creek rises on the border of Queensland and New South Wales, about 6 miles north-north-east of Stanthorpe, and flows in a general southerly direction to within 1½ miles of that town, when it bends to the south-east, and after several windings enters Quart-pot Creek. In its lower part it is known as Kettle Swamp and Law's Gully. Its fall is nowhere rapid, and its catchment area as a whole, especially near the creek itself, is flat. Machine Gully enters it from the east, about 3 miles north-east of Stanthorpe.

Tenure.—After most of the ground had been turned over by small claim holders, all likely ground was either selected or bought at auction, and is now freehold property. Thus, before operations can be started, arrangements have to be made with the owners, and it is generally conceded that the difficulty in coming to terms is one of the greatest drawbacks to alluvial mining in this district.

Messrs. Gibbs, Bright and Company some months since secured an option over the ground on Four-mile Creek from block 238 to 367 inclusive, a total length of 2 miles, of which probably only 1 mile will be dredgable. On the expiry of their option, being unable to obtain an extension, and their engineer (Mr. Hawley), having advised that the ground seemed worth prospecting, they decided to take a lease for fifteen years. This company is engaging on alluvial tin mining on a commercial base rather than a speculative one, finding that it is better to spend several hundred pounds on prospecting operations, and perchance prove the ground valueless, than to spend thousands installing costly machinery and then to make the same discovery or to find the material too poor to pay to work.

Prospecting.—Mr. Hawley, who is engineer in charge of operations, has been for several weeks surveying the ground to be prospected, and marking out the sites of the proposed bores. He himself took me over the leases, and has been good enough to give me the following particulars as to the work.

The method of prospecting employed here is that of 100 feet square intersections—lines of bores 100 feet apart being run along the creek and at right-angles to it. The ground between each four bores is assumed to contain the mean of the four results obtained. The average number of bores on each side of the creek is five (from three to seven), and there will be fifty-six rows along the creek, making, together with special bores (two rows on each side of Machine Gully), a total of about 600. It is believed that the average width will be 8 chains. The average depth of the ground to be dredged will be 7 to 8 feet.

Till lately only one boring plant was in operation, but a second was installed early in December, and in a short time a third was to be working, the three employing twelve to fifteen men for the following two months. By the end of January or the middle of February it was expected that sufficient information would have been collected for it to be decided whether the venture was worth going on with.

Each boring plant consists of a light derrick—three light timber legs with windlass attached—erected over the site of the bore for raising the boring apparatus, the lift amounting to about 20 feet. The only tools employed are a 5-inch auger (for surface work only), a 3¾-inch auger, a chisel, and an 18-inch pump for use inside the casing. These tools are attached to 1-inch square iron rods (made in 4-feet lengths), suspended from the derrick by a ⅜-inch wire rope connected to the windlass. The borehole is lined with ¼-inch iron casing, 4 inches in internal diameter, made in 4-feet lengths, with flush joints.

Four men are employed at each bore, one winchman, two sinkers—*i.e.*, men to remove and replace the tools and to give the augers the necessary turning movement while sinking—and one washer (who "pans off" the wash-dirt).

All the material raised is carefully transferred to a cubical box with 12-inch sides, the water is decanted, and the material is stamped down firmly and the height in the box measured. The contents are then calculated with the aid of a table, and checked by the calculated contents of the bore, the measured exceeding the calculated by an average of 5 per cent., owing to the washing in of the material round the bore hole. The whole is then carefully panned off, and the concentrates cleaned to an average of 74 per cent. tin, weighed to the nearest grain, and then from a table the amount of tin ore per cubic yard is found to within an estimated 2 per cent. of the actual contents.

The average rate per day is three to four bores (9 feet 6 inches deep) per plant. Exceptional depths of 22 and 23 feet are reached, but greater depths than 15 feet are seldom found. During the last fortnight (end November and beginning December) eighty-three bores had been put down with two plants (during part of the time), and sixty a week were expected with three plants in operation.

By the time prospecting operations have been finished here, £1,500 or £1,600 will have been expended, of which £750 or £1,000 will have been on boring alone—the average cost per foot here being 1s. 6d.

The Ground.—It is proposed to dredge only about 1½ mile of the lease—*i.e.*, from the centre of selection 253 to 259. The lowest part of the lease has

Plate 8.

Photo., L. C. B.

PROSPECTING BORING PLANT, 4-MILE CREEK, STANTHORPE.

Showing Auger, Pump, Cubical Contents Boxes, Etc.

been well turned over, but is separated by many chains of rocky ground from the main portion, and will therefore not be dredged. The richest part of the lease is about the mouth of Machine Gully, and from there it is intended to work Four-mile Creek down for half a mile and up for one mile, and Machine Gully up for half a mile. The ground has thus far proved very patchy, several parts being rich enough to pay for ground sluicing, while others are too poor for dredging. The few prospects I saw from the bores consisted in great part of "rosin" and ruby tinstone, free from black sand. The tailings distributed over most of the flat are said to contain from ½ to 1½ oz. of tinstone to the dish. The overburden has been proved to be practically barren of tinstone, and some method will be devised for getting rid of it without passing it through the tin-saving apparatus. The bedrock in the deeper dredgable parts is soft decomposed granite, which generally hardens as the rock approaches the surface up the sides, while the tinstone contents at the same time increase in coarseness. The slope on the western side is believed to be valueless for dredging, being poor and shallow.

Mr. Hawley informed me that from one of the first bores a pale straw-coloured diamond, of the size of a pea, was obtained.

The original owners of the land sank 260 bores on the 2 miles of the claim, but not in any sequence, and without including the 3 feet of surface material in their calculations; and, in consequence, an exaggerated idea of the amount of tinstone in the ground was formed.

Dredgers.—Owing to the general scarcity of water in this locality, it is not unlikely that a large dredger would be laid up during three or four months in a year, and Mr. Hawley will propose, if dredging is to be carried on, to install several small suction dredgers, worked by motors from one central electrical power station. The three great obstacles to dredging—want of water, layers of "cement," and huge boulders—would be thus to some extent overcome. One of the chief reasons for preferring the suction dredger is that the bedrock will be exposed to view, and, if decomposed, will not be broken into as it might if a bucket dredger did the work. The ground on the shallower slopes not to be reached by the dredger will be sluiced down with nozzles to within reach of the suction pipes. In addition, the smaller plants will be more mobile, and less time will be wasted in repairs. However, it will not be actually decided to install dredgers until the results of the bores have been obtained, though I think these have been, on the whole, favourable.

IV.—LODE TIN MINING.

Mr. Skertchley in his report* on the Stanthorpe district, says, p. 42:—

"I. The stream tin is not derived from lodes, but from two distinct sources of probably contemporaneous origin: (*a*) the greisen, or altered granite of the joint planes; (*b*) the dykes, chiefly elvan. . . . 3. The whole of the greisen and much of the elvan is, by constant weathering, releasing tin and forming what is known as surface tin. . . . quite crystalline and unworn. 7. The richness of the stream tin is no proof whatever, or even an indication, of the existence of rich lodes; but was due to the long-continued denudation of very widespread though poor stanniferous rock." With all this I am in entire agreement, except that it is quite possible, though perhaps not probable, that payable stanniferous lodes may yet be found.

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* *Op. cit.*

(a) The Ballandean Tin Mining Company.

The Ballandean Tin Mining Company has secured a lease from the owner of a 500-acre unconditional selection on the left bank of the Severn River, 6 miles west of Ballandean Railway Station, with the intention of testing several adjacent veinlets of tin ore outcropping on a ridge-top there.

The country rock is clay-slate which, along the joints striking about north-north-east to north-east, and dipping west-north-west, has been greisenised, and there carries bunches of large crystals of tinstone (½-inch diameter). These micaceous joints are found over a width of 107 feet on the surface, the total amount of tin present being only a fraction of a unit per cent. The hope was reasonable that a payable patch of tin ore might be found at a greater depth, and, therefore, an adit was opened from the west at about 40 feet below the hilltop, but though the main joints were found at 26, 44, and 61 feet to be mineralised with mispickel, they contain scarcely any tinstone. A drive is being opened to the south on the last mentioned joint, where there is 6 to 9 inches of quartz, besides 2 feet of cupriferous mispickel, which practically cuts out on the opposite side of the adit. The adit has been carried in a total of 81 feet. A small granite vein in the face points to the main granite mass being at no great depth. I can see no promise of a permanent lode being found here, but it might be some satisfaction to sink on the third vein to a depth of, say, 50 feet, as a bunch of rich ore might be found.

Rich stanniferous and mispickel-bearing veins (similar to those at Red Rock), on north-east joints are to be seen in the granite below the slates on the southern side of the Severn River, half a mile north-west of this adit. Several hundredweight of ore (50 per cent. tinstone) was obtained from one of these, and more could be got, but permanency is not to be expected. Several prospecting trenches were opened in the locality a few months ago, one of which exposes greisen carrying a little molybdenite and tinstone, but in too small quantities to be worth holding.

(b) Late Prospecting at Red Rock.

During the last month (November) two claims have been pegged out about a mile east-north-east of the Sundown Mine, on one of the branch gullies opening into Red Rock Creek. They are near the centre of an area formerly held under mining lease.

Mr. Skertchley refers to the granite boss of Red Rock as being euritic, with north-north-west master joints. Mr. Rands visited the locality in 1883, and found a shaft and trenches, reported to be on a 20-inch quartz reef, with strings of ore.

P. A. 49 (Morris Claim).—This, which is on the eastern side of the old M. L. 814, is reached after a stiff climb of over 550 feet down from the Sundown road. The country on the south is slate, but there is a gradual passage down the hill to the granite below. The Sundown Mine (in slate) is 1,200 feet below the range top, but the junction of the slate and granite here is only 750 feet below it, the granite having intruded further in to the slates here.

Morris has begun a shaft in altered slates containing mica, copper stains, and finely-disseminated tinstone, but as yet the formation is not well-defined, and enough work has not been done for its value to be determined.

About a chain to the north and 70 feet below is an old shaft on, to judge by the tip, felspar rock, containing crystals of tinstone up to ⅓-inch in diameter,

with veins of crystallised quartz. Some 50 yards below the shaft is an old open cut, the result of a company's work two or three years ago. The country here is still slate, the ore, bunches of tin-bearing quartz and soft replaced slate, occurring on joints. The company burnt and dollied the ore, which, to judge from what they left, must have been very rich.

P. A. 51 (Gunn's and Eli's Claim).—This adjoins P. A. 49 on the north, and is wholly in granite—very siliceous and felspathic, with joints striking north-east to east-north-east, and dipping south-east. At the north-eastern end of the tried ground is a trench 10 feet long and 2 feet deep, on a 6-inch vein of almost pure cassiterite, with a little soft matrix, in a joint in granular quartzose granite. Towards the south-west several small veins, carrying tinstone, have been exposed over a width of 5 feet, and the ore has been traced for 3 chains to the south-west. A shaft in slates on the ridge, a quarter of a mile beyond, is believed to be on the same line, though the tinstone has not been found beyond the granite. The prospectors wish to have a battery erected at once, but it would be much wiser for a small company to thoroughly test the ground by trenches and shallow shafts and crosscuts. The amount of work yet done is quite insufficient to show the nature of the deposits. The largest trench rather points to the main vein of ore pinching within a couple of feet of the surface. I am inclined to believe that the tinstone has, near the surface, been somewhat concentrated, not only mechanically but chemically. If the zone 5 feet wide is proved to carry 5 per cent. of tinstone, there should be no doubt as to the advisability of erecting a battery. A certain amount of difficulty will be experienced in reaching the main road, owing to a climb of over 1,000 feet within half a mile, but an entirely new road could be made, at some expense, round to the Red Rock Creek Crossing.

The other old workings in this locality were not seen.

2.—Notes on Copper and Silver Mines near Stanthorpe.

I.—SUNDOWN COPPER MINE.

Locality.—This is a reward copper claim—the old M. L. 24, the only one in existence of twenty-eight mining leases at one time held in the country between Red Rock and Sundown Creeks. It is on a branch gully from Sundown Creek, 3 miles above the Severn River and 28 miles south-west of Stanthorpe. The hills over which the Stanthorpe road passes rise 1,200 feet above the mine, within a distance of a mile, so that there was a great difficulty in making the road in the first place, and in using it in the second. It is proposed, in the event of operations being again begun, to construct an aerial tramway to do away with the necessity for the road for most purposes.

The only workings in existence at the time of Mr. Skertchley's visit* were on the opposite side of the creek (Clare's open cut). The last work was done in December, 1900, at which time £5,875 had been expended. The present holders are endeavouring to raise capital to prove the lode.

General Surface.—From the mine a tramline ran down to the reverberatory smelter, 7 chains distant. This put through 70 tons a week, the last smelting of 150 tons taking 16 days. The only building now standing besides the furnace-shed is the assay office.

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* *See* G.S.Q. Publication, 120.

Firewood was swung on wire ropes across to the furnace from the adjacent hills and ridges, it being impossible for vehicles to negotiate the country.

There is no natural permanent water supply here, the gullies being deep and narrow but short and steep, allowing the rain water falling in them to quickly run off. It would be possible to conserve a sufficient supply by one or more small dams.

Mine Workings.—The mine workings include an adit 270 feet in length along the lode—*i.e.*, to the north-east and east-north-east, about 50 feet above the bottom of the valley, and 70 feet below the ridge top. Half way in a 60-feet shaft connects with the surface, and at 100, 135, and 250 feet from the mouth are winzes 15, 50, and 26 feet deep respectively. At the bottom of the second winze drives 30 and 53 feet in length, south and north, have been opened, and are reported to be in ore. There is said to be 4 feet of ore in the bottom of the third winze. These are now all inaccessible, the main one being flooded.

An overhand stope extends from the mouth of the adit to within 50 feet of the end (where the lode is 3 feet 6 inches wide, with a 9-inch cherty centre) for from 20 to 10 feet above the drive.

The adit seems to have been opened in slate, but at 15 feet from the mouth grey arsenical material, 2 feet in width, begins, and continues for 5 feet, beyond which the stopes begin.

The ore is, as a rule, not easily separated from the country—gradually passing into it—but there are well-defined walls, within a few inches or a few feet of the lode. The lode increases in thickness from 2 feet near the mouth of the adit to 5 feet at the second (main) winze, then decreases to 3 feet, but again, at the third winze, spreads out to 7 feet width, including much country. It seems to have split up then, and one of the branches has been followed, and is widening in the face, where it contains (Government Analyst):—

Gold	...	...	16 gr. per ton
Silver	...	...	16 oz. „
Copper	...	...	11·8 per cent.

The main branch is probably to the east-south-east of the end of the adit. The lode is made up of lenticular bunches, as may be especially well seen at the top of the stopes near the shaft. Great and sudden variations in thickness sometimes take place within a few inches, owing to the occurrence of flat floors or flaws, and the ore extending further on one side than the other. The ore consists in greater part of mispickel, but with considerable quantities of chalcopyrite and quartz, and a little cassiterite.

In 1899, 30 tons of ore were sent to Cockle Creek, and ran 11½ per cent. copper, with silver and gold in addition. The last smelting (150 tons of ore) made locally, produced 25 tons of matte containing 29 per cent. copper, with 76 oz. silver and 6 dwt. gold per ton, showing that the ore averaged 4.83 per cent. copper, 12 oz. 13 dwt. silver per ton, and 1 dwt. gold per ton.

Geology.—The country rock is a highly altered, fine-grained sedimentary, the true bedding of which is not distinguishable, owing to metamorphism the secondary jointing. Granite is reported to occur on Mount McDonnell, 2 miles south-west of the mine, and on Mr. Skertchley's map a small patch is shown on the Severn River, just above the entrance of Sundown Creek. Their occurrence, together with that of the Red Rock boss, go to prove that the whole of the area is underlaid at no great distance by granite, though the mineralogical nature of the lodes would alone suffice to indicate that. It seems plain that

the minerals have been given off by the cooling intrusive granite, and precipitated in fissures and joints in the sedimentaries above. The ore deposits at Sundown all lie on one zone, but probably in separate fissures. It is quite possible, considering the small deposits of staniferous ores in the vicinity, that in the Sundown lode the amount of copper will decrease at a depth, and the tin increase. It is also most likely that there will be rich ore at the junction of the slates and granite.

II.—WORKINGS IN THE VICINITY OF THE SUNDOWN MINE.

Clare's Open Cut (the Great Eastern or Tin Mine), is 10 chains south-west across the gully from the mouth of the adit, and is included in M. L. 24. The tinstone is chiefly in joints in the slates, but where the rock is greisenised the mineral occurs throughout it, often included in mispickel which has replaced the slate; 20 tons of tinstone are said to have been obtained by dollying and sluicing a formation 7 feet wide.

A shaft was sunk in the bottom of the open cut, but has been filled in again. From the knowledge that the tinstone came from the granite below one would expect to find other deposits in depth, though prospecting for them might not be a payable venture. Wolfram was reported to have been almost as plentiful as tinstone, though little is now to be seen.

Beacroft's.—On the hillside, 330 feet above, and nearly half a mile south-west of the Sundown adit, are old workings on M. L. 23—trenches and potholes on the ridge-top, and shaft and open cut on the north-eastern slope. In the trenches vertical joints in slate are seen striking north-east, and along them lie bunches of mispickel carrying small crystals of tinstone. The main shaft is 30 feet below, and a chain north-east of the trenches; it is said to be 100 feet deep, but is now inaccessible. The mispickel ore obtained, together with a little pyrite and cupriferous pyrite, at a depth, carried small quantities of tinstone. The country is slate.

An open cut 10 yards to the north-east and 30 feet below the brace of the shaft simply shows, in much-jointed and impregnated slates, a zone 4 feet wide of stained and decomposed country with stanniferous mispickel ore in bunches up to 2 feet in diameter. The ore in the decomposed surface portion was washed in a cradle, to separate the tinstone.

An adit was begun 35 feet below, on a formation with slightly more tinstone than in the open cut, indicating a more promising state of things as the granite is approached. No copper carbonate is to be seen, but abundant scorodite (hydrous arsenate of iron).

About 10 chains north-east of the Sundown adit on the north-eastern side of the same ridge, arsenopyrite in slate has been trenched on, but little of promise can now be seen. A small open cut, 10 chains further up the ridge to the east-north-east, shows an interesting occurrence of pyrite, arsenopyrite, blende, cassiterite, hornblende, &c., in slate, proving the granite is at no great depth. Owing to the water in the open cut, the whole ore body could not be seen, but Mr. Skertchley gives its greatest width as 3 feet.

III.—SILVER QUEEN SILVER MINE.

The mineral lease (No. 72), of 40 acres, lies on the right bank of the Severn River, a little over 6 miles west of Ballandean Railway Station, and a mile west of the tin-sluicers' claims. It was secured in the beginning of 1899, and worked with sixteen men for two years, during which time £3,000 was spent on mining and road-making.

Workings.—Five shafts have been sunk along the line of lode. The main, or "prospecting" shaft (No. 5), is on the ridge-top, 50 feet above the river, and its total depth is 100 feet. At 35 feet depth is a level to the north-east for 10 feet, in slightly copper-stained strongly pyritous decomposed saccharoidal siliceous country, and another to the south-east for 6 feet in highly altered slightly copper-stained country. Ore is reported to have crossed the shaft between the 35 and 60-feet levels.

At 60 feet depth is a crosscut to the west for 10 feet to a winze on the lode, which here has a width of from 12 to 20 feet. This winze was also sunk to the 100-feet level, but, like the main shaft, it is now flooded below the 60-feet level.

Mr. Rodda, the former manager, has informed me that at the 100-feet level is a 30-feet crosscut to the west; and a drive, 100 feet in length, proves a shoot of ore 60 feet long. At the western end of the drive is a crosscut proved 20 feet of ore. The ore body in the No. 4 shaft at the surface was believed to have been cut by the eastern drive. A crosscut to the north reached slate in 40 feet.

About 500 tons of ore lie at grass, and rather more mullock. A sample of the ore assays (Government Analyst):—

Gold	... ...	16 gr. per ton
Silver	... ...	17 oz. 12 dwt. 0 gr. ,,
Copper	... ...	1·26 per cent.
Lead	... ...	7·0 ,,
Zinc	... ...	8·8 ,,

A trench to the west exposes fine-grained quartz-felspar-porphyry, but no ore. The ore has, however, been followed to the east to the river. The first shaft (No. 4), an underlie 70 feet deep, is 1 chain east of the main shaft; in it, or in the 17-feet crosscut on the south, at 50 feet depth, a little poor mispickel was found. The second (No. 3), 1 chain further east, is on pyritous stone, believed to be a formation. There is a big outcrop of decomposed porphyry, stained with copper carbonates, about a chain beyond, and an open cut, 10 yards across and 10 feet deep, with shallow shafts partly filled in. The ore raised here (about 10 tons of siliceous mispickel) does not look very promising. In the last shaft, half a chain beyond, only traces of ore were found. The river is only 30 feet below this.

Output.—Forty tons of picked ore have been sent to Cockle Creek, in different parcels, yielding from 2½ to 4½ per cent. copper, 15 per cent. lead, and 8½ to 16 oz. silver (average 12 oz.), the siliceous ore being richer in silver.

Geology.—These deposits consist of impregnations and replacements of the northern parts of a quartz-felspar-porphyry dyke (which is of extremely variable coarseness), the replacing minerals consisting chiefly of pyrite, with galena, chalcopyrite, and a little arsenopyrite, zincblende, &c., the last filling interspaces between the quartz crystals. The ore is bunchy, and, though the bunches may contain large quantities, work will be expensive. The value of the ore is stated to be about £4 a ton.

The presence of the blende is rather unfortunate, for the amount would be largely increased by concentration, though perhaps not to the extent of preventing the smelting of the concentrate. It is, however, possible that if the percentage proved very high the concentrates could be shipped to an oil-concentrating works, where there should be no difficulty in separating the minerals. Certain of the wet processes for copper extraction, such as Neill's or Van Arsdale's, or the new Hunt and Douglas, are as likely as any to enable this ore to be profitably treated.

Plate 9.

Photo, L.C.B.

GENERAL SURFACE VIEW, SILVER SPUR.

SHOWING WINDING HOUSE, POPPET LEGS, ROAST HEAPS, AND NEW AND OLD REVERBERATORY FURNACE SHEDS.

IV.—PIKEDALE SILVER MINE.

The Pikedale Silver Mine is on freehold block 802, near Pikedale Head Station, and within a few chains of the Silver Spur road, 20 miles west of Stanthorpe.

The mine is not now being worked, but was visited by Mr. Skertchley in 1897, a year before it closed.* There were then six shafts, the deepest 84 feet (now 170 feet) deep. Mr. Skertchley gives the thickness of the lode as from 1 to 3 feet. The ore contains silver, gold, copper, lead, zinc, iron, manganese, &c., but, unfortunately, no analyses have been published. A furnace was erected on the ground, and the matte produced shipped to Europe. Mr. W. G. Rodda, late manager of the mine, tells me that he smelted 750 tons of ore, producing 100 tons of matte, containing 30 to 40 per cent. copper, 150 to 300 oz. per ton silver, and ½ oz. per ton gold, valued at £3,000 in Swansea. This gives the contents of the ore as:—

Copper	...	...	4 to 5¼ per cent.
Silver ...	...	...	20 to 40 oz. per ton
Gold ...	...	...	1 dwt. 8 gr. per ton

Mr. Rodda affirms that the lode averages 6 feet in width, and contains from 2½ to 5¼ per cent. copper, and from 16 to 40 oz. (average 25 oz.) per ton silver.

The refractory nature of the ore seems to have caused some trouble, but the large amount of non-contributing shares are held to be the chief cause of the mine's present idleness.

3.—Notes on Mines near Texas (Stanthorpe District.)

1.—SILVER SPUR SILVER MINE.

(*a*) Locality.

Silver Spur lies west-south-west of Stanthorpe, 44 miles in a direct line, and 53½ miles by road. It is 6 miles east of Texas, and 3½ miles from the Severn or Dumaresque River. The main Stanthorpe road runs *viâ* Texas, and is 20 miles longer than the direct short cut from the mine, which the mail coach, running twice a week, now takes. Silver Spur township has a population of something over 200, depending absolutely on the mine, which it now practically encircles.

(*b*) History.

The discovery of copper-stained gossan was made in 1891 by one of the men employed at the Texas Copper Mine. A syndicate was formed, and sunk a prospecting shaft (No. 1) to 70 feet depth, for copper. Soon after the mine was "jumped" and held as a silver mine, the first specimen assayed yielding silver equivalent to 216 oz. silver per ton, the richest yet found. In November, 1892, the mine was purchased, a small company (24,000 shares of £1, paid up to 15s.), was formed, and has successfully carried on operations till the present, when prospects are brighter than at any previous time.

The mine is referred to at some length in Mr. Skertchley's report on the Stanthorpe district, already quoted,* and in an interesting paper by Mr. H. G. Stokes, read before the North of England Institute of Mining and Mechanical Engineers.

* G.S.Q. Publication, No. 120.

(c) Mining.

This mine is unique in Queensland, the deposits worked consiting of huge partly isolated leases. A relatively large amount of dead work is necessitated in exploitation, for though a shaft is sunk on each deposit, it has to be connected with the others for ventilation, exploration, and exploitation, making the total expenses of mining unusually great. The mining costs for the year 1901, exclusive of shaft-sinking and prospecting, were 16s. per ton, the work in the larger stopes costing 7s., and in the smaller 15s.

About thirty men are employed in connection with mining alone, half on the surface and half below, but a far greater number are engaged in wood-cutting, and timber, lime and matte carrying.

Comparatively small shafts (3 by 6 or 9 feet), have thus far been sunk, but the main shaft, now a little over 300 feet deep, in which most of the hauling is done, from between the 200 and 300 feet levels, where the No. 2 and No. 3 ore bodies and those below are being worked, is now being enlarged.

The levels are large, and need very little timber, but in the larger abandoned stopes passages have to be kept open by means of square set timbering. No timbering whatever is required while working in the sulphides.

The importance of prospecting is well understood at this mine, for in several instances new ore bodies have been found by breaking into the country adjacent to the workings; yet, at the present time very little exploratory work is going on. In fact, the main shaft is only a few feet below the 300-feet level, and this is especially surprising in view of the fact that an up-to-date reverberatory furnace is now in course of erection.

(d) Output.

The anual output of ore is about 4,000 tons, but a steady increase is now expected. At the end of last year (1903), there were 2,000 tons of ore on the surface. The amount actually smelted in 1903 amounted to 3,802 tons, yielding:—

Silver—96,000 oz.	valued at	£8,967
Lead—45 tons	„	517
Copper—31 tons	„	1,798
Gold—147 oz.	„	588
		£11,870

The total dividends to the present amount to £18,618.

(e) Surface Plant.

The winding is done by a 12-horsepower engine, geared to a 4-feet drum, and supplied with steam by a 52-horsepower Babcock and Wilcox boiler. In the same building is a Westinghouse Standard 12-horsepower engine and air compressor, delivering air at 70 lb. pressure to the two rock drills used in the mine. Adjacent to the engine-house is a small sawmill, which has been found necessary, owing to the isolated position of the mine, and has, besides, proved of considerable service to selectors in the district. Near the shaft is a "Giant" crusher, with 9 by 15 inch jaws, worked by its own 10-horsepower engine, and used for crushing the lime and quartz or siliceous ore from the mine used in smelting, the latter when the ore becomes too basic for the furnace—*i.e.*, when the silica contents fall below 20 per cent.

Plate 10.

Photo., L.C.B.

SURFACE PLANT, SILVER SPUR.

Showing Old Whim, Engine-house, No. 4 Shaft Poppet Legs, Main Shaft Poppet Legs, Rock Crusher, and Grizzlets.

(f) Geology.

The ore bodies occur in beds of dark-grey clay slates, which are interbedded with lighter clay slates, and the occurrence is due to strike faulting or crushing. Sandstones, conglomerates, and limestones, as well as schists and quartzites, occur in other parts of the district, and in some of the sandstones Permo-Carboniferous fossils have been found.* The average strike is north and south, with variable easterly dip. Numerous diorite dykes have been noted, one outcropping within 10 chains of the ore bodies. It is most probable that the ore-bearing solutions were derived from the deep-seated mass of which this dyke is an offshoot.

It has always been recognised that the Silver Spur ore bodies are closely connected with faults. At first it was thought that they were simply bunches attached to one main fault, striking about north-west. This fault is most strongly, or at least most plainly, developed at the north-western end, but towards the south-east it has split up into several nearly parallel branches, and it is difficult to say which is the main one, especially near the main shaft on the 200 and 300 feet levels, where the faults include ore bodies.

Several other faults abut against this main fissure on the south-west, generally normally. These are "strike faults" (the country having a strike of about north-north-east), and along them the country has been replaced by ore, the result being ore bodies. As a general rule the ore bodies are not adjacent to the main fissure in the upper levels, but approach it in depth, and seem there to be developing along it as well as on the fissures at right angles to it.

The main fissure (first found at 45 feet depth in No. 2 shaft), is tight, and never carries water, while the gossans and ore fissures are always saturated when first opened; it is strongly graphitic in places, especially in the central part of the workings and on the 300-feet level. At several places along the fault the country on the southern side is seen to be bent round to the west, near the fault, and therefore the country on the south has been shifted to the south-east, but it is not possible to give the amount of movement, either vertical or horizontal. The main fault was driven on to the south-east from the No. 2 shaft at 60 feet depth, and found to split at 50 feet distance. The country is crushed towards the end of the drive, and work stopped at a strongly mineralised promising-looking "floor," but a drive from the Long Drop shaft to the east is believed to be only 30 feet distant, and proved only a barren fissure.

It was the idea of Mr. Stokes, the former manager, that the fault splits at the 180-feet level, and that the deposits are included between the branches below; the present manager believes that the lower faults do not junction at the 180-feet level, but extend as parallel planes to the surface. There is nothing to support the latter hypothesis. This splitting of the faults has caused considerable uncertainty as to their relations to the ore bodies on the 150 and 300 feet levels, owing to some of them cutting across the bodies.

Ore.—The ore consists of a fine-grained crystalline mixture of galena and blende, with patches and bands of chalcopyrite and pyrite. That the ore has replaced country rock either where thin bedded or crushed (or in other places brecciated), is proved by a section in the drive along the main fault at the 200-feet level, where 2 feet of fissile ore occurs, identical in appearance with the adjacent country.

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* "Ore Deposits of Silver Spur." By H. G. Stokes, Proc. North of England Inst. of Min. and Mech. Engineers. 1899.

Formerly all quartz and quartzose ore were rejected, but the siliceous ore now being got—especially on the 300-feet level, where it contains ruby silver ore (silver sulphantimonide)—is richer than the clean sulphides, and the manager hopes to be able to work out much ore formerly left.

A granite pebble (white quartz, black biotite, pink felspar, and pinite) 3 inches in diameter, was found last year in the ore between the 200 and 300 feet levels in No. 3 ore body. While many of the pebbles found in the slates are due to movement and represent uncrushed country, these granite pebbles, of which several others have been found in the district, have been dropped from floating trees or ice, during the deposition of the sediments.

As the gossan was gradually worked out it was found necessary to work the sulphides, and some surprise was caused by their relatively high silver contents. (*See* analyses below.)

(*g*) Ore Bodies.

It was believed till lately that there were four main deposits, but the work on the 300-feet level has brought to light several additional deposits between No. 2 and No. 3 shafts. One of these bodies is the largest yet found, so the management have good cause to think that there is a bright future before the mine.

Ore Body No. 1.—The prospecting shaft, which is 150 feet deep, was begun on a small outcrop of copper-stained gossan, containing a little native silver. It is vertical to 60 feet, and then underlies steeply to the east to the bottom.

The ore body has now been practically worked out, though there are signs of it again at the 300-feet level. The gossan on the 60-feet level was worked for a distance of 130 feet north and south, with a width of from 5 to 25 feet, strings of ore still running on to the south beyond where worked, apparently well worth prospecting. The average value of the gossan was:—

Silver	30 oz. per ton
Gold	20 gr ,,
Copper	2·5 per cent.
Lead	5 to 6 ,,

but assays up to 6 oz. of gold per ton were obtained. The gossan passed into sulphide at 90 feet depth.

At the 100-feet level the average width was 10 feet, and small lenses of ore can here be seen on the eastern side of the face, replacing the clay slate country, while the western wall is slickensided and slightly graphitic. The hanging-wall is generally broken and mixed with ore. A tongue 8 feet wide, of 22-oz. ore, still remains at the south end, and will be worked in the future; 12 feet width of poorer ore (12-oz.) have also been left at the northern end, though it may improve within a foot. A block between the 80-feet and 100-feet levels is the only quantity of ore left in the No. 1 workings. A prospecting drive, known as "Hall's Folly," was carried 100 feet to the north-north-east of the main fault, at the northern extremity of this ore body, in unsuccessful search of other bodies. Much broken country, carrying an ounce of silver per ton, similar in appearance to the highly argentiferous country beside No. 4 body, was met 30 feet north of the fault.

At the 150-feet level the ore was worked over a length of 85 feet and a width of from 1 to 20 feet, but for only 20 feet below the level where it showed signs of "tonguing out." The body was thought to have pinched out here, but miners believe the small body on the 300-feet level is the same. The ore

is here broken up by floors dipping south-west, and similar in their occurrence to those in the country north of the main shaft. The sulphides from this body averaged:—

Silver	... ...	16 oz. per ton
Gold	... ...	1 dwt. „
Silica	... ...	26·25 per cent.
Sulphur	... ...	27·83 „
Iron	... ...	24·57 „
Zinc	... ...	11·40 „
Lead	... ...	6·46 „
Copper	... ...	2·20 „
Manganese dioxide		1·19 „
		100·00

The ore is composed of dense galena and blende with patches and bands of pyrite and chalcopyrite. A slight amount of poor quartzose gossany ore is now being got from the No. 1 body, for fetling purposes in the reverberatory furnace. A few small bunches of ore occur along the main fault between No. 1 and No. 2 ore bodies.

A strange body of ore came in at 170 feet depth, within a few feet of the No. 1 lode, and was followed up from the 200-feet level, on the northern side of the fault cutting off No. 1.

On the 200-feet level, 50 feet north-north-west of No. 2 shaft, a strong formation on a good fissure striking north-north-east has been taken to be the No. 1 body, but in the face of a drive running north-west from the shaft there is now a strong emission of carbon dioxide gas. No. 1 body having been "leady" and gaseous, it is expected that it will be found by continuing the drive.

Ore Body No. 2.—No. 2 shaft, 100 feet east by south of No. 1 shaft, was begun with the idea of striking the No. 1 ore body at a depth, and unexpectedly struck the No. 2 body, which did not actually reach the surface, though afterwards worked to within a few feet of it. It is now 317 feet deep, and used as a main hauling shaft, because of its central position; its dimensions above the 200-feet level are 9 by 3 feet, but below that 11 by 4 feet, the intention being to strip down the upper part when opportunity occurs.

The body near the surface had a length of 65 feet with an average width of 5 feet, while on the 56-feet level it had a total length of 110 feet, with a width of 2 to 10 feet. The southern half was gossan to 80 feet depth, the northern to only 45 feet, the two parts being supposed to be separated by the main fault. The oxidised condition of the southern portion is probably due to the slightly crushed nature of the country there. The slate pebbles found in the ore here may possibly be the harder uncrushed parts of the original country. The sudden variations in the size of the ore bodies is strongly marked on this level, where the ore suddenly increases from 1 or 2 feet to 6 feet in thickness at one of the "floors."

On the 100-feet level the body abuts against the fault, and averages 6 feet in width for 60 feet from the shaft, beyond which the drive was continued 15 feet further south, on formation, with occasional bunches of ore in clay slate. The crushed country to the east carries a little silver. The ore near the shaft is fissile, and the laminæ run in to the south-west (elsewhere they bend to the south-east), and, therefore, there is reason in believing the main fault is not here, but further north. On the southern side of the shaft small lenses have been followed for 100 feet, which, when bearing ruby silver ore, often

contain over 40 oz. silver per ton. The numerous lenses, the formation on the fissure, and the black shaley nature of the country, all indicate the presence of another ore body here. A winze sunk to the 150-feet level proved several overlapping lenses.

The No. 2 ore body was not worked below 130 feet depth, though the formation continues, the crushed country 10 feet west of the No. 2 shaft on the 150-feet level being believed to be the same. A formation occurs at the shaft, with veins and lumps of ore, and has been driven on to the south and south-east.

A small ore body, assumed to be No. 2, was struck 40 feet south-south-west of the shaft, on the 300-feet level. It carries from 3 dwt. up to 2 oz. gold per ton.

The country on the west side of the southern portion of the ore body is strongly slickensided.

Ore Body No. 3.—The No. 3 shaft, 240 feet south-south-east of No. 1 shaft, was begun on a small outcrop of gossan 70 feet long and 1 to 8 feet wide, but the large amount of water in the lode prevented exploitation for several years. When the water was finally overcome, the deposit proved to contain some of the richest ore yet found there, and has now, in consequence, been worked out.

At the 50-feet level the body is 100 feet long, and up to 30 feet wide; a strong fissure connects the body with the main fault 100 feet distant. Lenticular masses of quartz, probably older than the ore, occur on the eastern side of the deposit at the 60-feet level. As the ore body pitches towards the north, the southern end passes through the shaft at 90 feet depth at the water level.

On the 90-feet level the ore was 20 feet wide a little north of the shaft, but it gradually contracts to the faulted face, 60 feet from the shaft, where the country is considerably veined with translucent selenite. The country there is a pebble-bearing clay slate, with all the appearance of a "crush conglomerate."

At the 150-feet level ore occurs at the north-east corner of the No. 2 shaft, and also in the shaft, but its relation to the other deposits cannot be seen. The No. 3 body is 130 feet long and 5 feet wide on this level, and is reached by a crosscut from the No. 2 shaft. The ore, 10 to 12 feet in width, has been stoped right to the surface from the level; that underfoot is siliceous, and worth, as far as known, only £2 a ton, but will be made available as a flux, and in working may be found to contain rich ore. A long tongue and several small lenses were followed by a prospecting drive to the south; these lenses of ore occur between the laminæ of the slate, which are themselves often converted into ore, and may be due to the deposition of the ore, for they are not found elsewhere. The drive was carried on along the eastern wall for some distance south of the main body.

Work is now being carried on at 190 feet depth, where there are 10 feet of sulphides, and towards the south 12 inches of clay on the hanging-wall carrying 40 oz. silver. One man during the twelve months prior to October had broken down 400 tons, and is now stoping upwards. The country here is massive grey clay slate; on the east it is shattered, graphitic, and clay-stained.

The ore on the 200-feet level was struck by driving 40 feet south of the No. 2 shaft, when strong gas was emitted by the ore body. The body has quite lately been proved within a few feet of the shaft. Ore has been proved for 40 feet under the 200-feet level. It is 30 feet wide in one place (10 feet of which is poor), but within 30 feet it pinches to 1 foot, and varies from 6 to 12 inches to the winze 160 feet south of the shaft, beyond which the formation

still continues. Ruby silver was first found in the northern part of the body here, and 54-oz. ore is still underfoot. A winze 30 feet deep has been sunk on 2 feet of ore near the end, and proves that the ore at that depth is widening towards the north.

The country on this level is strongly graphitic. Some trouble is now found in identifying the main fault on this level, it having formerly been held that it passed within 2 feet north of the shaft, but there is reason for believing that the fault lying 15 feet north of the shaft is the main one, in which case the few hundred tons of ore north of the shaft may be on the usual (the southern) side of the fault. Numerous lenses have been worked out between the 200 and 100 feet levels on the north side of the shaft. A fault running to the north-west from the shaft proved to have several ore bodies on the northern side, one of which, at 50 feet from the shaft, was followed, and led to the discovery of several other lenses.

Considerable prospecting has been undertaken on this level along the fault north-west of the main shaft, in search of Nos. 1 and 4 ore bodies, but only formations were found, the latter gaseous. The formations will be further prospected by drives to the south, as the ore is generally not well developed near the main fault.

A main winze in the central part of the body passes at 240 feet depth out of the No. 3 body into another coming in from the south (the big body on the 300-feet level). The latter is being driven on to the south at the 250-feet level, and is widening out in that direction. The ore is very fine-grained, and contains lenses of graphitic slate. Work is also going on in the No. 3 body, on the same level, showing it to increase from 6 feet on the south to 15 feet on the north, of which, however, 8 feet is zinciferous (45 per cent. zinc). In the face is a strong fissure—the main fault—near which ruby silver occurs in the ore, causing it sometimes to yield 110 oz. of silver per ton. The deposit here has good walls dipping east, that on the western side being strongly slickensided.

The large body of ore on the 300-feet level was struck 50 feet south of the main shaft by a crosscut, which, after passing through foliated carbonaceous clay slate with irregularly folded lumps of calcite, gradually entered highly zinciferous ore, of which there are 10 feet still standing. The "smelter ore," carrying 30 oz. silver, was then proved to be 30 feet wide, but the ore pinched out within 50 feet to the south, though the formation continues, and appears to be increasing in size; the edge pitches south, an unusual thing in this mine. It was not worked northwards towards the fault because its value decreased. The ore is now being shot down from the stopes above already referred to. A crosscut was continued 25 feet to the east, in search of another body, but except water, lime, and ironstains (promising signs here) nothing was found.

Another body of ore was found by following a fault about 20 feet to the north-north-west of the shaft; it contains ruby silver, and is the richest in lead in the mine. Ore is now being broken down here. The same slickensided graphitic fault with foliated country was followed to the south-east, but only small lenses of ore were found. Driving is still being carried on, the large quantity of chalybeate water being a most encouraging sign.

Ore Body No. 4.—The No. 4 shaft, 110 feet north-north-west of No. 1 shaft, was sunk after the discovery, in 1896, of the No. 4 ore body by a drive, a chain in length, along the fault from No. 1 ore body. The ore, the gossan portion of which carried 50 oz. silver per ton, did not reach to within 35 feet of the surface. With the exception of a little sulphide, the body is now worked out. The average length of the body was 30 feet, and the width 3½ feet, but on the southern and eastern side, above the water-level, the broken country

for 3 feet from the lode averaged 50 oz. of silver per ton, but contained up to 90 oz. per ton. This argentiferous country was discovered by working away auriferous siliceous flux adjacent to it; and very often it was impossible to tell, except by assay, whether the material was silver-bearing or not.

At the 30-feet level a strong "pug" fault, striking north-north-east, and dipping 1 in 3 to the west-north-west, bounds the deposit on the south. At the south end of the 50-feet level 2 feet of 12-oz. sulphide-bearing country has been left for the present. The change from gossan took place at 80 feet depth. At the northern end the face is 15 feet wide, strongly copper-stained siliceous gossan and sulphide ore, with partly replaced "augen" (ore) slate. Innumerable small irregular bunches and veins of ore pass into the country from this body. The ore pinched to a small vein at 90 feet depth.

Intermittent prospecting with a 1-inch handpower diamond drill is going on for the body on the 150-feet level. The hole (now 8 feet in), is being put in diagonally from the drive on the main fault, 50 or 60 feet from the No. 1 body, to catch the formation exposed 20 feet further along the drive, the hope being that ore may be developed as usual at some distance from the main fault. This formation, which is accompanied by a body 1 to 3 feet thick of sulphide and quartz, bends round, and follows the fault for 10 feet to the north-west. Beyond that the fault continues without "pug," mineral, or graphite, and with no sign of other ore body. Lawson's drive, only 20 feet beyond, struck the fault in a similar condition, so that this end seems least favourable for ore bodies.

This body was never highly zinciferous, but was rich in lead and silver, one lot of 1,000 tons of ore yielding a total of 70,000 oz. of silver.

Shaft No. 5.—The No. 5 shaft, known as the Long Drop, lies 260 feet south-east by east of No. 1 shaft, and is 80 feet deep. A fissure—probably parallel to the main fault of the mine, and 1½ chains to the north—was struck, but no ore was found.

Besides these shafts a main mullock pass, a chain north of the No. 3 shaft, connects the 300-feet level with the surface.

Lawson's Shaft.—This, the only other shaft in the immediate vicinity, is just outside the lease, 200 feet north-north-west of No. 1 shaft. It is 71 feet deep, with a crosscut 20 feet long to the fault on the north. No ore was found here.

A small patch of lead carbonate ore occurred on the surface between Nos. 1 and 4 shafts. It worked out at 30 feet below the surface, where it came against the main fault.

There are rumours of a specimen having been found *in situ* in the early days near where the smelters now stand, and prospecting may yet be done there. A little ore was also found in the north-west corner of M. L. 54, but cut out in the trench.

(*h*) Treatment.

The mine being situated on a long slope above the Severn River flats, there has been no difficulty in arranging the surface plant. The ore raised is run in the trucks on an overhead tramway and tipped on to an upper grizzley (1-inch bars with 2-inch spaces), over a second (1¼-inch by ⅜-inch bars and 1-inch spaces). A very small proportion of the fines from the grizzley (3 to 6 cwt. to a charge), is sent to the smelter, a small quantity is spread over the roast heaps, and the greater part goes to a spoil heap, now containing about 1,500 tons, to treat which it is considered a mechanical roaster will be necessary. There have, in fact, been rumours lately of the company undertaking the erection of a roaster for this ore.

Plate 11

Photo., L.C B.

ROAST HEAPS, SILVER SPUR.

SHOWING HEAP IN COURSE OF PREPARATION, HEAP UNDERGOING ROAST, AND ROASTED HEAP.

Plate 12.

Photo., L.C.B.

COPPER REVERBERATORY FURNACE, SILVER SPUR.

Showing Mine in the Background.

Roast.—The coarser and medium ore from the grizzley is then trucked directly along a tramline running over roast heaps, and tipped as necessary. These roast heaps or kilns as they are called, are built up over 2 feet of firewood. The coarsest material (from the upper grizzley), is first thrown down to a depth of 4 feet, and then the ore caught on the second grizzley is tipped and knapped down and spread out by a gang of four men. This is then covered by a thin layer of fines to choke the draughts and prevent fusion of the ore, which is extremely likely to occur, owing to the short time available for the roast. The heaps are 15 yards long, 5 yards broad, and 6 feet deep, and contain on an average 500 tons of ore. Quite lately is has been made the practice to roast the siliceous and basic ores separately, no extra cost being entailed, as the ores generally occur in separate parts of the deposits. One heap of basic ore, containing about 630 tons, was burning during my visit; another of basic and one of siliceous ore had been roasted, and a fourth of siliceous ore was being prepared. The total in the heaps then amounted to 1,500 tons.

The roast takes from two to three months, the sulphur contents being reduced from 28.5 to 14 per cent. Heap-roasting here costs about 2s. per ton of ore (when employing four men on the heaps), and to this amount the firewood (obtained at 10s. per cord) contributes 4½d. When the roast is over it is often necessary to blast down parts of the heap, owing to fusion having taken place.

Reverberatory Furnace.—The roasted ore is carted to the trucks and trammed to the reverberatory furnace, into which it is charged from above. The furnace has a single hearth, and takes a total charge of 84 cwt. (of which 14 cwt. is lime, with an occasional addition of iron ore). This is put through in six or seven hours, making a total of about 15 tons a day. The slags now being produced contain only 2 oz. silver per ton, and the manager is confident that that amount could be reduced by a longer run, which would, however, result in no actual saving.

An attempt has been made to liquate from the old chrome (hearth) lining, when broken up, some of the rich matte absorbed by it; but after the liquation it still contained 150 oz. silver, so an attempt was made to slag off the chromite by the addition of silica. It was found that for the operation to be a commercial success it will have to be done in a blast furnace.

In the operation of smelting the zinc is wasted, but the lead, silver, gold, and copper are saved to a greater or less extent. A parcel of matte shipped in September last ran over 1,000 oz. of silver per ton, and the average content of gold is 1 oz. 6 dwt. per ton (though only a few pennyweights in the ore), amounting to 500 or 600 oz. a year. The following averages of analyses made by Mr. Leon Meston during 1900 are the latest available for the whole process:—

—	Sulphides.	Roasted Ore.	Matte.
Gangue (SiO_2)...	14·20	21·43	Trace
Iron ...	16·14	14·07	5·55
Lead ...	13·08	10·70	39·30
Zinc ...	25·30	24·66	2·33
Sulphur ...	28·50	13·87	19·136
Copper ...	1·083	1·296	31·50
Alumina, loss, &c. ...	...	13·974	...
Silver ...	26·38 oz. per ton	...	1·89
	98·303	100·00	99·676

Later analyses of the ore (also by Mr. Meston) show that the calcium carbonate amounts to less than 1 per cent., alumina to 5 per cent., and arsenic a trace only; also, that during 1900, 1901, and 1902 the amount of silica gradually decreased, the iron decreased nearly 30 per cent., the zinc slightly increased, the lead decreased, and the copper increased very slightly. In connection with the above analyses it may be of interest to give the smelting returns for the year 1901. These have been placed at my disposal by Mr. H. A. Stokes, who was then general manager:—

Ore Smelted.	Flux.	Matte.	Silver.	Gold.	Lead.	Copper.
		Tons.	Oz.	Oz.	Tons.	Tons.
	...	4	2,144	2	1·52	1·29
2695·99 tons ...	72·45	87·55	• 47,440	59	22	26·5
	1·50	...	@ 2s. 3d.	@ £4	...	@ £55
2695·99 tons	73·95	87·55	£5,337	£236	22	£1,457 10s.

The furnace ran 243 days in the year on heap-roasted sulphide ore. The "matte fall" was 3.36 per cent., and a concentration from 29.73 tons of ore was made to 1 ton of matte.

The total smelting costs for 1901, including superintendence, labour (nine men), fuel, flux, stores, ore carting, freights, and bank and insurance charges, amounted to £1 2s. 10d., the grand total (mining and smelting) per ton of ore raised being £2 7s. 6d.

A new reverberatory furnace is now being erected. The diameters of the hearth will be 15 and 30 feet—area 362 square feet—making it one of the largest copper furnaces in Australia, its estimated capacity being 25 tons a day. The hearth, which has a fall of 6 inches in the 30 feet, is built of a course of firebrick on two courses of ordinary brick, above concrete, supported by three arches, through which a current of air will circulate for the double purpose of cooling the hearth, and of becoming heated itself before admission to the furnace. The roof will be 4 feet above the hearth at the upper end, and 3 feet 6 inches at the lower. The fire grate will be 5 feet in length. The furnace will have three side doors for ravelling, and a tap-hole at the lower end. On the sides where the matte touches will be a lining of chrome-brick, in the making of which a considerable amount of experimental work has been done.

The chromite is obtained from Wyalda, in New South Wales, 35s. a ton being paid for it, delivered at Inverell Railway Station. This involves a train journey of 472 miles to Stanthorpe (at, say, 1d. per ton mile), and then cartage over 50 miles to the mine (at 30s. per ton of back loading, otherwise £2 a ton). The hardest and least friable brick thus far has been obtained by the ignition of a mixture of chromite and talc (?) obtained in the mine, but, as the supply of the latter mineral was soon exhausted, recourse had to be taken to ordinary clay, the best results with which were from a mixture of 75 per cent. chromite and 25 per cent. clay.

Blast Furnace.—A small blast furnace was erected in 1900, owing to the then high price of lead (£17 9s. per ton) to treat the old reverberatory furnace slags, which it has been calculated could be made to pay with the price at £13 10s. By the time the first shipment was ready the price had fallen to £11, and operations were then suspended. The slags, of which there is an accumulation of many thousand tons, contain from 4 to 5 oz. silver, 11 to 14 per cent. lead (the latter from the oxidised ore), and 20 per cent. zinc;

Plate 13.

Photo., L.C.B.

OLD LEAD BLAST FURNACE, SILVER SPUR.

SHOWING THE BLOWER AND THE SPIRAL TUBULAR WATER JACKET.

3,721 tons of slag, with 21 tons of ore, were put through during 1901 (163 working days), the actual contents being 7.7 oz. silver, 11½ per cent. lead, 14.6 per cent. ZnO, and 34 per cent. $Si\,O_2$, requiring 1,414 tons of limestone (at 6s. per ton delivered), and 399 tons of ironstone flux (at 10s. per ton, delivered at works). As a result, 33½ oz. gold, 28,896 oz. silver, 8½ tons copper, and 188½ tons of lead were saved, at a profit up till December, when the market fell.

The furnace contained a novel feature in its water-jacket (Hickson's idea), which consisted of 3-inch iron pipes coated with clay. These pipes were built up in the form of a rectangular spiral for a height of 4 feet above the crucible, and connected with a reservoir overhead. The water used at that time was very impure, and it was found that the lowermost pipes soon became coated internally, and in consequence were burnt through. Mr. Hall proposes as an amendment that the pipes, instead of being all connected in a single spiral, should be built up as separate rings. A number of taps to regulate the flow of water would then be required, but time might be saved in case a pipe had to be removed.

The brick shaft above the jacket is 10 feet by 5 feet in section, and 8 feet high. This is considered too low, and the cause, owing to the small blast, of the comparatively great loss of metal in the slags—viz., 1 to 2 per cent. lead, 16 dwt. silver, and 15 to 20 per cent. zinc. The blower in use was capable of giving 5,000 cubic feet of air per minute at a pressure of 5 lb., but the actual pressure used was from 6 oz. down to 2 oz. There were 7 tueyeres on each side of the furnace.

Another unusual feature of the work here was the use of coal instead of coke, it having been proved to give a cleaner lead slag than coke, and with a consumption only 4 per cent. greater. The coal was obtained from Fraser's Creek, near Ashford, in New South Wales, 30 miles distant from the Spur, a lease being held by the Silver Spur Company. The cartage to the smelters amounted to 25s. per ton. The ash varies from 6 to 20 per cent., and the carbon averages 62 to 63 per cent., though it runs up to 70 per cent. The following section is shown on the company's plan:—

	Ft.	In.
Hard coal (hanging-wall), worked for smelter ...	9	0
Friable coal (white ash), for smithy	9	0
Hard coal	9	6
Shale, with coal bands	8	0
Hard coal	6	6
Coal	1	10
Shale	6	0

The seams dip 1 in 2 horizontal, and have been worked to 52 feet depth.

Coal occurs also at Bonshaw, nearer Silver Spur, but, like the country, it is crushed and contorted, and contains much pyrite.

Pyritic Smelter.—Before opening out on the 300-feet level it was expected that the ore there would be much poorer in silver, and presumably in zinc also, than that above. A modern pyritic blast furnace was therefore installed, but before arrangements were quite complete for making a start, it was found that very little decrease had taken place in the value of the ore, the contents now being nearly 30 oz. silver, 12 per cent. lead, and 25 per cent. zinc. It was then decided not to employ the blast furnace, the reason given being that one-third of the silver would be lost by volatilisation with the lead fumes, owing to the carbonaceous fuel, but the large amount of zinc in the ore must have been a controlling factor.

The furnace included many of the lastest improvements, some of which were looked upon as experimental, and its estimated capacity is from 125 to 170 tons a day. It is circular in section. The crucible is lined for 2 feet from the base with chrome brick, above which is 2 feet of a hollow air-cooled casting, and then 2 feet 6 inches water-jacket, surmounted by a brickwork shaft 5 feet in height. The firebrick-lined tueyeres (Austin's patent), were designed to act like blow-pipes, producer gas (formed in a patent generator consuming wood), being mixed with the blast air at the moment of admission to the furnace. The reducing fusion and most intense action were thus concentrated at the mouths of the tueyeres.

Another special contrivance is the feeding apparatus, also designed by Austin, to obviate premature fusion of the charge at the mouth of the furnace. By it the flux is charged at the circumference of the furnace, and the ore in the centre; the centre is practically gastight, owing to the fusion of the ore. Fumes and gases were to be taken off below the charging floor, and conducted to a settling flue, 1½ chains long and 6 feet across, before passing to the stack.

Fuel and Flures.—The immediate vicinity of the mine is now stripped of timber, and the getters have sometimes to go several miles for the necessary material.

The lime for flux and building purposes is obtained from two localities, the one 4 miles east, the other 6 miles north, of the mine. At the latter place ironstone also occurs, and there is good timber in the same direction, but a stiff climb of 400 feet from the mine on to the tableland 2 miles distant, rather handicaps the locality.

On Hughes' selection, 4 miles east of Silver Spur, are two main limestone outcrops. The southern has a width of about a chain, and a length of 2 chains, striking a little east of north. The rock has a bluish colour, and is marked with white veinlets; it assays 94 per cent. calcium carbonate. No mining or quarrying has yet been done, the surface blocks having been simply broken up and carted away. Two other smaller outcrops occur on the same line, within 5 chains to the south, where the country rock is slate, quartzite, and jasperoid. The limestone forms lenticular masses, and has no sign of fossil remains. At the northern occurrence half a mile distant the blocks outcrop on a flat, and are therefore less easy to load than at the southern locality. The company pays 2s. 6d. per ton for breaking the stone and carting it in to the mine.

The limestone area, 6 miles north of the Spur, is at least a mile in diameter, the rock outcropping at intervals over a wide flat, now covered with a dense growth of weeds, rendering it impossible to determine the exact extent. The area includes slates and ironstones.

The main ironstone outcrop is 6½ miles north of the Mine. It consists of three lenticular masses, separated by a few feet; the central is 1 chain long and 10 feet wide, that on the east is 6 feet long and 2 feet wide, that on the west 6 feet long and 3 feet wide. Their strike is north-west. The central outcrop stood 6 feet above the ground, but several hundred tons have been removed from it for flux. The greater part of the ore is brown limonite, but crystalline magnetite is also sometimes found; parts of it are full of grains of quartz, particularly on the eastern side, where it has a brecciated structure.

Calcareous sinter occurs between the eastern and central outcrops, but the country rock cannot be seen because of abundant red soil and thick vegetation.

A shaft has been sunk 10 yards south-west of the deposit, and passes through slickensided clay slates to a depth of 50 feet. It was sunk in order to prospect the lode for copper, because of a few stains on the surface, a crosscut being carried from the bottom to the lode, but a large amount of water coming in the shaft had to be abandoned. Sinking on the ore, though more expensive, would have given some knowledge of the deposit. It is very unlikely that any quantity, more than a unit or two per cent., will be found here. The following is an analysis by Mr. Leon Meston from a 12-ton lot:—

$Fe_2 O_3$	... ...	85·22—*i.e.*, Fe = 59·66
$Fe O$		
$Mn O_2$, &c.	...	1·69
$Al_2 O_3$	... ...	5·50
$Si O_2$	... ...	4·94
$H_2 O$	... ...	2·65
		100·00

The ore cost 10s. per ton, delivered at the works (*i.e.*, 8s. breaking and carting, and 2s. explosives).

In conclusion, I should remark that I am indebted to Mr. E. Hall, the present manager of the mine, for much of the above information, but I am under still greater obligation to Mr. H. G. Stokes, the former manager. It was understood from Mr. Hall that the workings have not yet been surveyed and planned. Until the survey has been made no certain geological work can be done in the mine.

II.—TEXAS COPPER MINE.

Texas Copper Mine lies 2½ miles west of Silver Spur, and was abandoned in 1894, so that the surface only can now be inspected. The country rock is siliceous clay slate.

A siliceous gossan outcrop containing a little copper was first worked. At 60 feet depth the copper ore cut out and work was stopped. A vertical shaft was then sunk on a fissure to the north, and several isolated patches of copper ore were found, but nothing further was done on the main line.

III.—SILVER KING SILVER-LEAD MINE.

Silver King Silver-Lead Mine lies 2 miles north-north-west of Silver Spur, and was opened in 1893. The country rock is "knoten" schistose slate, with lenses of limestone. The outcrop of carbonates of lead and copper in gossan was 30 feet long and up to 5 feet wide, the ore having partly replaced a zone of country rock. There were no defining walls, and the ore gradually disappeared at about 30 feet depth. Ore amounting to 30 or 40 tons was raised and yielded 50 oz. silver per ton, and 5 per cent. lead.

IV.—SILVER CROWN SILVER-COPPER MINE.

This abandoned mine lies 4 miles east of Silver Spur. Small pockets of cupriferous gossan in clay schists, dipping 80 degrees to south-south-east, were found near the surface, but galena and copper pyrite appeared at 50 feet depth. The ore assayed from 5 to 40 oz. of silver per ton, and 14 per cent. of copper.

9th March, 1904.

4.—Appendix.

The following additional notes on the condition of mining at Stanthorpe were made during a short visit at the end of May, 1904.

GROUND-SLUICING, SEVERN RIVER.

Mr. Baker, who at the time of my last visit was preparing to work two claims on the bank of the Severn River, below Ballandean, has informed me that before operations had been going on long enough to prove the ground the lease expired, and as an extension could not be obtained the claims were thrown idle. It is understood that only a small quantity of tinstone was saved.

STANTHORPE PROPRIETARY TIN DREDGING COMPANY.

The following returns are from the Warden at Stanthorpe:—

January to April (inclusive) 1904 ... ... 6½ tons tinstone.

Mr. Martyn informed me that six weeks were lost during the quarter, so that the average output of the dredger per working week was 13 cwt. One shift only was working during that time, but in future three will be kept going.

As the result of this measure of success it was decided to carry out certain alterations, and for that reason the dredger has been laid up since Easter. It is expected that work will not be commenced again before the middle of June.

Among the improvements now being carried out on the dredger is the dropping of the top works (tables, launders, &c.) two feet, allowing the drop-shoot to be carried further under the buckets for the purpose of catching sticky material not thrown out immediately the bucket passes the top tumbler. This will also allow more room on the grizzley, where "Martyn's automatic hoes" are to be employed. The "hoes" consist of half-inch iron plate, hung from endless chain-link belts, and travelling along the bars in the same direction as the "wash," but at a greater speed (150 feet a minute), the object of this addition being to break up the clayey material and force it between the bars of the grizzley.

Another alteration is in the sluice-boxes. Four only will be kept on each side, and these have been lengthened to 15 feet, with ten feet between centres of the rake shafts.

During the last few months two dams have been constructed on Quart-pot Creek, one about half a mile above and the other one and a-half mile above the dredger. A third, half a mile above the last, is now under construction, and it is expected that the three will hold 7,000,000 gallons of water, sufficient to supply the dredger for four months. Before the construction of these dams water had to be obtained by pumping from waterholes in Quart-pot Creek into the Chinaman's race, and the difficulty in obtaining water is held to have been the cause of the smallness of the above output.

It should have been mentioned that Mr. Martyn, who is now managing the dredger, held it on tribute from the company till Christmas last, and it was due to his foresight in keeping on till this year, when stanniferous ground was entered, that the dredger was not dismantled.

BROADWATER PROPRIETARY TIN DREDGING COMPANY.

Two of the dams on this company's leases have been repaired since Christmas, and the dredger has been refloated.

Mr. Martyn has found that the overburden and tailings are practically valueless (contrast with the Brisbane Claim, where two-thirds of the tinstone is in the overburden), and they will therefore be raised and deposited without being passed over the tables. The "wash" will then be raised, and it is expected that two tables will be able to cope with it. The material resembling that at Wylie Creek, the arrangement of the plant will be similar to that in operation there, but the boxes will be longer, and will be provided with mechanical rakes as on the Stanthorpe Proprietary dredger.

PROSPECTING ON FOUR-MILE CREEK.

Prospecting operations have now been completed, and though no word has been received from the principals (Messrs. Gibbs, Bright, and Company), there seems to be every probability of the scheme outlined above being carried out. It may be mentioned that ground carrying one and a-half pounds tinstone to the cubic yard is the poorest that will be worked.

SILVER QUEEN SILVER MINE.

This mine has now been taken up by the Messrs. Baker Brothers, who have pumped out the main shaft to the 100-feet level.

Sixty tons of the ore at grass have just been sent to Aldershot for a trial concentration by Wilfley table. Mr. Baker's own assays of the ore on the surface, after concentrating three to one, average:—

Lead	... ...	40 per cent.
Copper	... ...	6 „
Silver	... ...	64 oz. per ton.

This is considerably higher than the return from my rough surface sample from the same ore heaps, and if correct, with lead at £11 10s. per ton, copper at £56 10s. per ton, and silver at 2s. 1d. per oz., the gross value of the concentrates would be £14 13s. 1½d. per ton. Were the reduction company to pay for both lead and copper, which is not very likely, the smelting charges would reduce this amount by at least one-half (*vide* tariffs), unless special arrangements could be made.

Mr. Baker believes the ore can be mined at 6s. per ton, and crushed and jigged for 7s. a ton, and he puts freight and cartage of the concentrates to Aldershot at £1 15s. In my opinion mining costs would be at least 12s. per ton, making the total cost of a ton of concentrates, delivered at Aldershot, £4 12s.

In case no arrangements can be made with the smelters, it might be possible to save all the metals and receive full value by first extracting the copper by a wet process (for which the ore seems to be specially adapted) and then the lead and silver from the residue by smelting.

2nd June, 1904.

By Authority: George Arthur Vaughan, Government Printer, Brisbane.

Queensland.

DEPARTMENT OF MINES.

GEOLOGICAL SURVEY OF QUEENSLAND.
Publication No. 192.

REPORT.

THE HERBERTON TIN FIELD.

(WITH MAP.)

BY

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ASSISTANT GOVERNMENT GEOLOGIST.

BRISBANE:
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1904.

LETTER OF TRANSMITTAL.

30th March, 1904.

SIR,—I have the honour to forward herewith for publication a report by Mr. Cameron, Assistant Government Geologist, on the Herberton Tin Field. The report treats on the geology of the ore deposits, and descriptions are given of as many of the mines as could be examined at the time. Some historical and statistical information concerning the field is also included.

I have, &c.,

B. DUNSTAN,
Acting Government Geologist.

The Under Secretary for Mines,
Department of Mines, Brisbane.

CONTENTS.

REPORT ON THE HERBERTON TIN FIELD.

I.—INTRODUCTORY AND TOPOGRAPHICAL.

The Herberton Tin Field lies among the hilly country to the west of the Herberton range, at the heads of the Herbert, Walsh, and Tate Rivers, the centre of the district being about 50 miles south-west of the port of Cairns. It is approached from that port by the railway line to Chillagoe, which crosses the north-west corner of the field, and from which three branch lines strike in southerly directions to different portions of it.

The railway line from Cairns ascends the valley of the Barron River, as far as Mareeba, 46 miles from Cairns and 1,300 feet above it on the coastal plateau to the east of the ranges. It then leaves that valley, and, continuing south-westerly, crosses the divide on to the waters of the Walsh River, which flows westerly into the Gulf of Carpentaria.

The first branch line breaks off at Mareeba, and continues up the valley of the Barron as far as Atherton, near the foot of the main range. The eastern portion of the tinfield is connected with this terminus at Atherton by a good road over the range to Herberton, which is situated 12 miles off on the head-waters of the Upper Herbert or Wild River, at a height of 2,900 feet above the sea.

The second branch line approaching the tinfield is the privately owned tramline of the Stannary Hills Company. It leaves the Chillagoe line at Boonmoo, 81 miles from Cairns, and ascends the valley of Eureka Creek, one of the heads of the Walsh River, for 14 miles. This line connects the mines belonging to the Stannary Hills Company with the main line, and taps generally the traffic of the central portion of the field, including the treatment works and mines of the important mining centre of Irvinebank.

The third branch line is the privately-owned railway line of the Mount Garnet Railway and Mines Company. It leaves the main line at Lappa, near the north-western corner of the field, 102 miles from Cairns, and, passing across the heads of the Tate River, gives communication with the western and southern portions of the field.

The continuation of the main line from Mareeba to Chillagoe, and the construction of these three branches towards the tinfield, have all been completed within the last three years. This rapid construction was the outcome of a sudden increase in the prices of tin and copper, and a consequent attempt to place the mining for these metals on a more permanent and scientific footing. Its effect has been to enormously facilitate communication from the coast to the field, with a consequent reduction in the expenses of mining and prospecting.

The tin mines are scattered over an area of some 12,000 square miles. This country is amongst the most mountainous in Queensland, ranging from 2,000 to 4,000 feet above the sea. It is traversed from south-west to north-east by the main dividing range of the State, which forms the parting between the head-waters of the rivers flowing to the east coast, and those flowing west to the Gulf of Carpentaria. This range of hills rises to its highest

altitudes in Mount Stewart's Head, on the eastern edge of the field, near Herberton, this mountain, according to S. B. J. Skertchly being 4,400 feet* above the sea.

North-east of Herberton the range bifurcates. One spur goes northerly as a continuation of the main divide, parting the head-waters of the Walsh from those of the Barron. Its altitude gradually lessens till, at a point about 18 miles north of Herberton, where it is crossed by the Cairns to Chillagoe Railway line, it is no longer recognisable as a range,-but forms an almost level plain at a height of about 1,700 feet, with the waters of the Barron flowing to one side and those of the Walsh to the other.

The second spur runs south-easterly in an opposite direction, hemming in the head-waters of the Herbert River. The two spurs form a rampart parallel with the coast, and at a distance of some 30 miles from it, presenting an abrupt face towards it for some 60 miles in length, and cutting off the tinfield from easy communication with it. At the foot and up the sides of this range extends a belt of basalt country, thickly covered with scrub. which has greatly added to the difficulties of surmounting the range. Till within recent years the whole of the traffic passed through the northern end of this scrub from the terminus of the railway line at Mareeba, by Atherton, and over the range by a steep ascent to the head-waters of the Wild River at Herberton. Of recent years the construction of the Chillagoe Railway line and its branches has drawn off a considerable amount of the traffic in a northerly direction.

The tin mines lie scattered in groups down both sides of the main divide, the greater number being within a radius of some 50 miles from a central point. The rugged nature of the greater portion of this district, and the consequent high cost of haulage of ores and machinery, has added greatly to the expenses of development of the mines. With the extension of railway and tramway communication, the latter of these two factors has been considerably reduced, but the haulage of ores from the numerous mines scattered about the hillsides to places convenient for treatment, is still a very heavy item in mining costs, and one to which the greatest attention must be paid in any scheme of profitable development.

II.—GEOLOGY OF THE ORE DEPOSITS.

The oldest rock formation of the Heberton Tin Field is a series of alternating coarse and fine sedimentary beds. They have been folded and faulted by pressures acting from east and west, and are now generally found lying at high angles of inclination, their irregular and broken lines of strike running in northerly to north-westerly directions. These rocks have been altered by long ages of pressure and chemical change, till their coarser beds have been metamorphosed into quartzites and greywackes, and their finer beds into slates and schists. Subsequent denudation has removed them over the greater portion of the tin-bearing area, and has thus exposed the underlying granite rocks over the greater part of the district.

The sedimentary rocks cover a large area in the centre of the district south from Irvinebank, and occur also in smaller areas near Watsonville, Stannary Hills, Koorboora, and California Creek. Their boundaries are only roughly defined on the map, the time at the disposal of the writer, the scanty nature of the topography, and unsurveyed character of the greater portion of the district not having allowed of their being accurately

* Tin Mines of Watsonville. S.B.J.S. G. S. Q. Publication No. 119. *See* Map.

mapped. A great number, perhaps the greater number of the more important lodes, are associated with these rocks, occurring generally in the coarser greywackes and quartzites.

The plutonic rocks consist mainly of holo-crystalline types of biotite or hornblende granite. There are, however, large areas of euritic types, such as granite porphyry, and quartz felsite. Lodes of tin occur in both. Dykes of elvan intrude both the plutonic and altered sedimentary rocks.

The tin lodes are for the most part very irregular in their manner of occurrence. The deposits of ore seldom lie along a well-defined course between walls of country rock, but are, as a rule, distributed through it in an irregular manner, forming bodies of very varied size and shape. The lode material is only in exceptional cases separated by well-marked planes of division from the enclosing country. As a rule it merges into it with a gradual change from lode material to barren rock. The lode material is in almost all cases evidently a product of the alteration of the country rock by the action of mineralising agents, which have changed its constitution by chemical action, and have at the same time deposited tin and other minerals within its interstices.

In the case of the granitic rocks the alteration to lode material takes many forms, giving a variety of ores of widely differing appearances. The alteration varies, however, more in degree than in general character, and can, as a rule, be readily understood. The felspar and other silicates may be changed to serpentine or chlorite, or may be completely replaced by silica. In other cases the products of alteration are sericite and silica. In some cases very little alteration is noticeable to the eye, the tin occurring in grains through the apparently unaltered granite or porphyry. The results are ores varying through every degree of alteration, from the normal granite rock, splashed through with grains of tin, to purely silicious tin-bearing material.

In the sedimetary rocks the lode material varies from an almost unaltered quartzite, showing under the microscope crystals of tin in the interstices between its grains, to a massive green chlorite, which weathers on the surface to a rusty-red kaolinic material. A normal sample of "chlorite ore" from the 500-feet level in the Vulcan Mine, showed under the microscope a mass of grains of quartz and felted patches of chlorite, splashed through with crystalline grains of tin and magnetite. In the alteration of these greywacke and quartzite rocks also, the silicate minerals have evidently been first attacked, and changed into chlorite by the mineralising solutions.

The fluoric minerals—topaz, fluorspar, and tourmaline—generally found associated with tin deposits, are of very usual occurrence, both in the lodes in the granite, and those in the sedimentary rocks, while the metallic minerals—wolfram, bismuthine, antimonite, galena, chalcoprite, and magnetite—are frequent accompaniments, often in sufficient quantities to be a source of considerable trouble in the treatment of the ore.

Mr. Jack, in his report on the mines near Herberton and Watsonville,* thus discusses the manner of formation of the ore bodies:—

One fact unnoticed and unsuspected when I wrote my first report comes out clearly and unmistakably from a detailed examination of the field, now that something more than the mere surface is accessible to observation. That fact is the intimate connection of the tin deposits with metamorphosed igneous dykes. Such dykes, emanating from a deep-seated reservoir of molten matter, forced their way under pressure into fissures in the solid porphyry rock and consolidated as basic igneous rocks. The basic rocks of the dykes seem to have undergone a gradual process of metamorphism. The dykes now consist mainly of quartzose chlorite and occasionally of quartzose serpentine. It may be inferred that they were originally consolidated as quartz diorites or as rocks more or less of the basaltic type. The tin occurs in floors, veins, or pipes among the joint-planes of the dykes.

* *Opus cit.*, page 30.

It is quite possible that the tin may have come up in the first instance molten with the molten mineral matter of the dyke. In that case it is probable that it was afterwards dissolved and redeposited in the open joint-planes of the dyke. A further separation and redistribution may have taken place simultaneously with the chemical or electric action which resulted in the metamorphism of the dykes.

On the other hand, the tin may have first come up in solution, after the consolidation of the dykes, along the walls of the latter and among the fissures and joint-planes by which they were traversed, and been deposited there. A re-solution of the tin ore would probably take place on the metamorphism of the dykes; and as the metamorphosed dykes had probably a new joint-system developed in them, a further concentration of the ore may have taken place.

In any case there is nothing to favour the supposition that waters containing tin in solution and circulating through the upper portion of the earth's crust failed to deposit tin ore in the porphyry, but deposited it immediately on meeting with the metamorphosed dykes. On the other hand, there are good grounds for supposing that the tin was carried up, either with the dykes in a molten condition or was carried up in solution by mineral waters along the lines of the dykes. In either case the permeation of the adjacent porphyry by the mineral waters may explain the occasional occurrence of tin ore in the "country rock." In either case, as the dykes have originated in a deep-seated mass of molten matter, they may be expected to carry the tin ore to greater depths than are ever likely to be reached by mining. The metamorphosed dykes are traversed by a series of dykes of quartz porphyry, strictly analogous to the elvans of Cornwall. They do not, however, appear to be in this field prolific sources of ore. Indeed, the Three Star and Herberton Ironclad elvans are almost the only known cases of stanniferous elvan. It appears, however, from the cases of the Erin-go-Bragh and Southern Cross that the elvans have occasionally served to reopen the basic dykes and permit of a further local deposition of tin ore.

In the light of more extended developments of the lodes of this district, and of the now almost universally accepted theory—first enunciated by Daubree and subsequently developed by other French investigators—as to the method of introduction of tin into lodes, I do not think that Mr. Jack's theory of their intimate connection with altered basic dykes can be accepted as an explanation of the cause of their formation. An examination of the geological conditions obtaining in the Great Northern, Vulcan, Great Southern, Alhambra, Smith's Creek, Ivanhoe, Extended, and many other lodes, shows no such connection. The chloritic and serpentinous gangue materials of each of these lodes can, I am of opinion, only be explained as the result of the alteration *in situ* of the country in which they occur, by the action of mineralising vapours and solutions. Genetically there seems little doubt that the lodes owe their presence to the intrusion and solidification of the granite mass in and around which they occur, their metallic contents having been extracted from the molten granitic magma in the form of gaseous sulphides, fluorides, and borides, as the mass solidified downwards and became creviced and cracked on its outer surface. The fracturing of the overlying sedimentary rocks, near their contact with the heated granite, would allow of the permeation into them also of these metal-bearing vapours. The subsequent precipitation of their metallic contents, with an accompanying change of the wall rocks of the fissures, would be brought about on their meeting with the cooler streams of the meteoric waters descending from the upper portions of the earth's crust.

If this theory of the mode of formation can be accepted for the tin deposits of this district, the cooling rocks on either side of the outer edge of the granite mass at the time of its intrusion would thus be the chief seat of tin deposition. The prevalence of the tin lodes on both sides of the contacts of granite with the overlying sedimentary rocks, as is seen by a glance at the accompanying map, lends colour to the applicability of this theory as to their origin in the district under review. The dissemination of the tin in crystalline grains through these altered zones of rock, and often through rock which shows little sign of alteration, can more readily be understood on the hypothesis that it was introduced in a form so capable of permeating rock masses on either side of open fissures than on any other.

The applicability or otherwise of this theory may have an important practical bearing. Many of the larger lodes are being worked in the sedimentary rocks close to their contact with the granite. If the source of the tin is the everywhere underlying granite, it may possibly be that as that rock is approached the deposits of ore will become richer and larger. On the other hand, since the first introduction of the tin, there has probably been considerable reconcentration of the metallic contents by the circulation of the ground water, as the surface level has been lowered by denudation. This may have so overbalanced the tendency to enrichment as the granite is approached, that quite the contrary may be the case. The evidence collected by the writer was not sufficiently detailed to allow of any opinion being formed on this important question.

In a few cases the ore deposits are associated with dykes of elvan, and, possibly, of diorite, the parting between the dyke rock and the country having formed a line of weakness by means of which the mineralising agents were enabled to gain access from below, and alter the rock on either side to lode formation. The Gully lode at Herberton was apparently an example of lode material formed alongside of an elvan dyke, and, according to Skertchly, many of the lodes at Watsonville were found associated with dykes of diorite. In his report on this district Skertchly says:* "There are no lodes in the whole district but are associated with either elvans or basic dykes." This statement is, however, much too general to be accepted for the whole of the district, for in the case of many of the most important lodes there is no sign of any connection with intrusions of igneous rock.

In the greater number of cases the fracturing of the rocks by the pressures to which they have been subjected by earth movement, has apparently been quite sufficient to allow of their permeation by the mineral-bearing vapours from below. The irregular character of the tin deposits seems to be due primarily to the irregular disposition of these fissures and fractures through the country. The alteration of the rock and deposition of mineral in the neighbourhood of these fractures followed no regular plan, but apparently occurred wherever local conditions were favourable to their permeation by the mineralising vapours and solutions. The prevalence of the occurrence of large ore bodies in the harder greywackes and sandstones of the sedimentary series and their scarcity in the softer and finer-grained schists is interesting in this connection, as it can easily be imagined that, owing to their greater hardness and less flexibility, the former rocks would be more likely to form open fissures under the influences of strains, while the coarseness of their grain would probably afford freer access to the permeation of solutions through their mass.

In many cases this irregular disposition of the fractures which have determined the admission of the lode material, has given rise to large bunches of rich ore showing little trace of any connection with other deposits. This seems to have been especially the case in the ore bodies found in the granite, though it obtained very frequently also in those occurring in the sedimentary rocks. Large and rich bodies of ore have to all appearance completely cut out within a few feet of the surface, leaving no clue that could be traced down to any similar and connected occurrence of ore below. The theory of the introduction of the mineralising agent in gaseous form, which would presumably allow of their passing through fissures of the rock for long distances, where the conditions were not favourable to permeation on either side, no doubt explains such occurrences. In many cases lodes, after apparently "petering out" completely, have been picked up again by following down narrow strings of mineral, or by haphazard prospecting at greater depths, and

* *Op. cit.*, page 45.

have opened out into bodies of as great or even greater extent than those that led to their being prospected. Thus the Vulcan lode at Irvinebank has been worked to a depth of 700 feet, though the lode was on two occasions completely lost as work proceeded downwards.

III.—CHARACTER OF THE MINING.

The irregular manner of occurrence of the ore in these lodes has had a marked influence on the character of the mining in this district. In the case of mineral matter introduced along true fissures, extending with comparative regularity over considerable distances both horizontally and vertically, and carrying lode material between well-defined walls, or impregnating the country rock more or less evenly on either side, a certain amount of confidence can be displayed in prospecting and development work. If the lode becomes too narrow or too poor for profitable working, development work is pushed on either horizontally or in depth along the line of fissure. with a fair prospect of the lode again widening or improving in value along the same line. Where, however, no such irregularity of disposition of the ore exists, as in the case of most of the Herberton lodes, only the general run of the ore body can be followed as a guide for fresh prospecting work.

One of the most noticeable features of the ore bodies is the shortness of the shoots in horizontal extent. In the Launcelot Mine at Newellton, at the 150-feet level, the lode has been stoped for 200 feet continuously on ore. The next longest working on a continuous body is at the 500-feet in the Vulcan Mine, where the stope has been carried along for about 150 feet on ore. At the 100-feet level in the Smith's Creek Mine the ore was taken out for about 78 feet in length. These, however, are three of the longest continuous shoots that have been worked on the field, the majority rarely reaching 50 feet in length. Nor do they often lead on to others in the same line, connected genetically with them, and capable of being worked from the same shaft.

Their want of length is often compensated for, to some extent, by considerable thickness, and bodies of ore, of nearly the same dimensions in either direction, are of frequent occurrence.

The greatest hindrance to continuous and economic mining of these lodes is, however, the want of continuity of the shoots of ore as they are followed downwards. Repeated instances of unsuccessful attempts to pick up large and profitable shoots of ore by driving 50 feet or 100 feet below where they are being stoped, have convinced the tin-miner in this district that his hopes of picking up a lost lode again in the position in which it might naturally be expected, are more often disappointed than not. Frequently a long period of prospecting in different directions has to be gone through before fresh ore reserves can be developed, with often little or no indication except the general dip of the shoot above to serve as a guide.

The want of continuity of the deposits makes the economic location and proving of fresh ore reserves, in advance of those already developed and in course of extraction, a matter of the greatest importance. Where the lodes follow no true course, as such is understood with true fissure lodes, and where the break in continuity is not due to a faulting of the country subsequent to the formation of the ore body, it is useless to attempt to apply rules of procedure for finding lost lodes that have been framed to suit well-defined deposits with definite course and dip. The only course open seems to be that universally adopted by the experienced tin-miner—namely, to follow the tin as far as it will lead, in the hopes of its making into another body of ore, and when this can no longer be done, to use the individual judgment in prospecting in the most

likely place in the most economic manner that can be employed. In this connection it seems likely that, in the case of large bodies of ore like those found in the Vulcan, Smith's Creek, and many other mines where the tin is disseminated with comparative evenness through an extensive mass of lode material, the diamond drill might be employed with advantage by saving much profitless driving and sinking, and allowing of the opening up of fresh ground in the most convenient manner. In any case, the importance of keeping development work well ahead of present mill requirements cannot be too strongly insisted on with lodes of this character, if the undertaking is to prove profitable to the shareholders.

The small size of the great majority of the lodes, combined with their richness, has made them peculiarly adapted to return good profits to small parties of working miners. Their bunchiness and want of regular continuity when followed downward frequently gave rise to correspondingly irregular methods of working, often entailing two or three handlings of the ore before it could be brought to the surface. In this way depths were soon reached at which it became impossible to handle anything but the richest ores at a profit, and the majority of the lodes were gradually abandoned before any great depths had been reached. Many of the larger ore bodies, especially amongst those occurring in the sedimentary rocks, were early found to be too poor for profitable mining with the low price ruling for tin before 1898. They were abandoned at shallow depths. Increased prices, however, inspired the hope that many of these could be made to yield profits if provided with batteries close at hand, and with the application of more up-to-date methods of mining.

It is lodes of this character, some of them scarcely prospected before, that have attracted attention of late years at Coolgarra, Stannary Hills, Koorboora, and other places. They have accounted for a large proportion of the increased yield during the last three years, and must be looked to to maintain the output in the future.

The varied character of these lodes demands considerable originality of treatment in each case, both as to the method to be employed in mining them and in the subsequent treatment of the ore. The uniform methods generally found prevailing on all mines of one particular field must be diversified here to suit the peculiarities of each lode. There is, in fact, scope on this field for the employment of the best mining skill available, if waste of funds in unprofitable surface works and unsuitable mining methods is to be avoided, and the lower grade propositions are to be made remunerative.

IV.—HISTORICAL AND STATISTICAL.

Alluvial tin was first worked behind the coast range in the early part of 1880, on Prospector's Gully, near the present town of Herberton. The first lode—the "Gully" lode of the Great Northern Freehold—was found a little higher up the same gully a few months afterwards. Stream tin had been worked previously to this on Tinaroo Creek, east of the coast range, but apparently it was not till the opening of the ports of Cairns and Port Douglas in 1879 that much attention was paid to the mineral deposits west of the range. Mr. Jack, who visited the Herberton lodes in 1880, thus describes the history of their discovery:—*

This neighbourhood was described by Mulligan as stanniferous as much as six years ago (1874), but as there was then no nearer port than Cooktown, the expense of land carriage would, of course, have rendered the working of tin unremunerative. The harbours of Cairns and Port Douglas having, however, at length been opened, and the basaltic regions in the valleys of the

* Report on the Wild River Tin Mines, 1880. R.L.J., Geological Survey Publication No. 10.

Herbert and Barron having been taken up in squatting runs, attention was again directed to the tin deposits. Mr. Atherton, of Emerald End, on the Barron, having found stream and surface tin in sufficient quantities to warrant further prospecting, took up John Newell and several others from Tinaroo (about 30 miles off) to the heads of the Wild River in the latter end of 1879. This party found stream tin in payable quantities in Prospector's Gully, on the left bank of the Wild River, near the present township of Herberton. Four months later William Jack and party explored the neighbourhood of Prospector's Gully, and were rewarded by the discovery of the Great Northern lode. Other lodes were quickly found and taken up by the miners, who shortly afterwards rushed the ground.

The discovery of the lodes near Herberton, and of the Great Western and other lodes in the neighbourhood of Watsonville, some 5 miles further west, led to the taking up of a great many claims in these localities. Mr. Jack, in his first report, describes as many as 109 in these two districts. During the next year a considerable amount of ore was raised and stacked, awaiting the erection of crushing machinery. Crushing began in 1883, and for the first year 12,405 tons of stone were treated for a return of 2,646 tons of black tin. In 1885 the battery at Irvinebank commenced crushing, chiefly on ore from the Great Southern Mine, and this place gradually became a most important centre. Up till 1890 the mining industry in these three localities was in a flourishing condition, and returned 15,000 tons of black tin, valued at £650,000. Batteries were also erected at Return Creek in 1885, Eureka Creek and Glen Linedale in 1888, and California Creek in 1890, but by the end of the latter year they had all ceased to work. From that time on the low prices of tin, together with the exhaustion of the surface deposits, and the more readily accessible bodies of ore, led to the closing down of many of the mines, and a considerable falling off in the output of tin. The success attending the opening up of the Vulcan Mine, however, in 1891, and the regular output from the large bodies of ore developed, kept life in the district, and afforded the sinews of war for continuous prospecting. From 1891 to 1902 the Vulcan Mine furnished more than half the total return of lode tin from the whole field, with an average yearly output of nearly 450 tons.

The sudden increase in the value of tin in 1898 led to a marked revival of interest in the field, and was followed by the formation of a number of companies. The aim of these companies was to secure groups of abandoned or languishing mines, with the intention of developing and working them in a more systematic manner than had been attempted previously.

Of these companies the Coolgarra Company at Return Creek, the Stannary Hills Company at Eureka Creek, the Launcelot Company at Newellton, the Great Northern Company at Herberton, and the Cuprite Company at Irvinebank, have been the most active, while the mines at Koorboora have been vigorously prospected by the Irvinebank Mining Company.

At this latter place a 10-head battery was erected near the Shakespeare Mine in 1899. It has been working with fair regularity since, and has crushed some 11,500 tons of ore for a return of 341½ tons of black tin, valued at £19,416.

The Coolgarra Company having erected a new 10-head battery on Return Creek, commenced crushing in March, 1901, and continued with little interruption till September of 1903. There had been no crushings at this place since 1888. The total for the last period was 21,879 tons of stone for a return of 473 tons of black tin, valued at £22,646. The greater portion of this stone has come from the Alhambra Mine. The low grade of this ore compelled the closing down of the mine in September last.

The Stannary Hills Company secured the most important mines on Eureka Creek, which had been abandoned since 1893. A tramline connecting these

mines with the Chillagoe Railway line, 14 miles off, and with a 20-head battery on the Walsh River, 5 miles further east, has since been completed. The survey of the line was commenced in 1898, and the construction completed in 1902. The battery commenced crushing in August of last year, and up to the end of the year had put through 5,660 tons of stone for a return of 209 tons 17 cwt. of black tin, valued at £15,848.

The Launcelot Mine, near Newellton, on the Dry River, 7 miles south-west of Herberton, was discovered about 1895 by Harrod, and some good crushings were obtained from it at the Bischoff Mill. In 1899 the mine was bought by Mr. C. C. Clotten, of Frankfort, and the property floated into a company called the Launcelot Tin Mines. A large dam was constructed on the Dry River, and dressing machinery for a 5-head battery imported from Germany. The erection of this machinery was completed by the end of 1901, and crushing commenced in May, 1902. Three shafts have been sunk to a depth of 150 feet, and up to the end of 1903 4,190 tons of ore have been crushed for a return of 494 tons of black tin, valued at £28,234. The company have since commenced to further sink their shaft, and are proceeding with the erection of an additional 10-head of stamps.

The Great Northern Company commenced to sink the shaft on the "Eastern" lode of the Great Northern Freehold, near Herberton, which had been full of water since 1891, in June 1901. It was sunk from the 400-feet to the 700-feet level, and, during the present year, the lode was again intersected at that depth by a short drive from the bottom of the shaft. A battery is now in course of erection to treat the ore thus developed.

The Cuprite Company, at Watsonville, secured a block of ground on the hills to the south of the township of Watsonville, embracing a number of the best-producing mines in this neighbourhood. Since 1899 they have done a considerable amount of prospecting, but so far without much success.

In addition to these new batteries on old mines, there is to be noted the finding of the Smith's Creek Mine during the latter end of 1901, and the erection of a battery consisting of three Huntingdon mills and modern dressing machinery. This mine commenced crushing in January, 1903, and since then has turned out 585 tons of tin, valued at £41,093, from 18,674 tons of stone. Unfortunately, the lode has been lost below the 100-feet level, and at present there is no further ore in sight, but with further prospecting it may be expected that additional reserves will be found, and the life of the mine continued.

The addition to the field of the new crushing power detailed above has led to a marked increase in the output of tin for the last three years. For the three years preceding 1901 the average yield was a little over 600 tons of black tin per annum. Since then it has rapidly increased, till for last year it totalled some 2,268 tons, or nearly three and a-half times the former yield.

The increase in the amount of stone crushed is even more noticeable, the average percentage of the ore having been reduced by over two-fifths. This is clearly shown by the table giving the yield of the field from the commencement of crushing (Table I.). The reduction is accounted for by the fact that the increased value of the metal, combined with the erection of up-to-date mills in close proximity to large bodies of ore, has allowed of the profitable treatment of large quantities of stone which would have been too poor to pay under the old conditions of low values and long haulage to the mills.

Notwithstanding this large increase in the output of lode tin, none of the new ventures have as yet been able to become dividend-paying. The expenses of the large amount of surface work in the erection of mills, winding machinery,

and tramways, have been very heavy, and in many cases the returns have not been up to expectations. The want of continuity of the ore bodies, and the difficulties of estimating reserves, has been the source of great trouble in preventing the mills from being regularly supplied, and has greatly added to the cost of mining. The Coolgarra Company closed down in September of last year, and the Smith's Creek Mine had crushed all their available ore by the end of the year. The Stannary Hills crushings have not turned out up to the expectations created by the estimates of value and quantity reported from time to time from the mine. Only at the Launcelot Mine, and at Koorboora, have the crushings been both regular and of good value, and in the case of the former the greater portion of the profits has been absorbed in providing capital for further development.

The following table gives the amount of stone crushed and tin obtained in the Herberton District from the year 1883 to the year 1903, both inclusive :—

TABLE I.

AMOUNTS OF STONE CRUSHED AND BLACK TIN OBTAINED, HERBERTON DISTRICT, FROM 1883 TO 1903.

Year.	Stone Crushed.	Yield of Tin Ore.	Percentage.	Value.	Value per Ton of Black Tin.
	Tons.	Tons.		£	£
1883	12,405	2,646	21·3	No records	No records
1884	11,031	1,902	17·25	,,	,,
1885	12,834	2,096	16·32	,,	,,
1886	14,816	2,198	14·8	,,	,,
1887	12,142	1,508	12·42	,,	,,
1888	11,159	1,390	11·70	76,400	50
1889	14,476	1,560	11·02	90,000	49 10s.
1890	13,700	1,699	12·3	104,050	49 18s.
1891	6,718	1,063	15·8	68,850	50
1892	9,481	1,181	12·46	69,450	50
1893	9,749	1,215	12·46	72,000	45
1894	7,211	1,250	17·33	67,300	35
1895	6,779	1,036	15·28	43,300	30
1896	6,630	747	11·26	31,770	30
1897	7,128	749	10·51	27,967	30
1898	5,306	508	9·57	16,618	32·71
1899	7,135	682	9·57	40,865	59·90
1900	6,544	665	10·16	40,310	60·61
1901	15,268	910	5·96	46,733	69·79
1902	26,190	1,524	5·82	76,462	50·17
1903	51,577	2,268	4·39	135,735	59·84

V.—THE MINES.

(1.)—THE HERBERTON DISTRICT.

The lodes in the neighbourhood of Herberton were vigorously worked for the first ten years after their discovery. Several shafts were sunk, reaching in the case of the Great Northern lodes to depths of 400 feet and 500 feet. During this period, according to the official returns, these lodes produced some 6,704 tons of black tin, valued at about £335,200. Of this the two lodes on the Great Northern Freehold produced 4,130 tons, and the remaining lodes 2,574 tons. Mr. Jack inspected these mines in 1883, and in his report describes some 66 different claims. At that time the deepest workings were on the Great Northern lodes, at depths of 60 feet and 124 feet. The exhaustion of the surface deposits and the difficulties generally experienced in picking up the lodes when lost, led to the gradual abandonment of most of these mines. For the next ten years, from 1891 to 1900, the return of tin amounted to only

590 tons. Lode mining practically ceased in 1899, and was not renewed till the middle of 1901. The shaft on the Great Northern "Eastern Lode" was then bailed out, and the sinking of the shaft recommenced.

This was the only mine working at the time of my visit, and consequently was the only point at which the manner of occurrence of the tin in these lodes could be studied in detail.

The lodes lie mostly among the hills to the east of the town, all within an area of about 2 square miles.

The country rock is a normal biotite granite, which is traversed by numerous dykes of a pinkish or whitish elvan. The ore bodies seem to have been exceedingly irregular in character, but to have afforded wonderfully rich ore on the whole. The total stone treated for the first ten years shows an average of black tin of over 21 per cent. for over 32,000 tons of stone. Of these lodes the St. Patrick, Bradlaugh, Southern Cross, Wild Irishman, and Black King were the better known, but as none of them had been working except occasionally in a desultory way for some years previous to my visit, I found it practically impossible to obtain any reliable information about them.

Table II. gives the official returns of ore crushed from the mines near Herberton as far as they have been recorded.

TABLE II.

OFFICIAL RETURNS OF ORE FROM MINES CRUSHING AT HERBERTON FROM 1883 TO 1903.

(Abstracted from Wardens' Reports.)

Year.	Total from all Mines, Crushed at Herberton Company's Mill.		Great Northern Company's Gully Lode.		Great Northern Company's East Lode.	
	Stone.	Black Tin.	Stone.	Black Tin.	Stone	Black Tin.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1883	8,950	1,889	4,500 tons of stone gave 1,240 tons of black tin from both mines.			
1884	8,965	1,509	1,400	420	600	150
1885	2,423	563	1,400	400	300	100
1886	2,869	530	800	240	180	42
1887	2,519	560	850	130	950	236
1888	2,222	506	600	180	1,000	300
1889	2,063	454	99	40	1,161	314
1890	2,550	658	...	...	1,200	336
1891	1,290	232	...	...	980	196
1892	1,451	137	...	...	...	...
1893	723	153	...	...	..	...
1894	869	128	...	...	...	...
1895	443	44	...	...	...	...
1896	583	54	...	...	...	...
1897	211	37	...	...	...	...
1898	608	37	...	...	...	...
1899-1903... ...	...	...	...	...	...	...
Totals ...	38,739	7,491	5,149	1,860	6,371	1,674

THE GREAT NORTHERN FREEHOLD.

The workings on this property, which is 60 acres in extent, are within half a mile of the town of Herberton. The ground was taken up in 1880 as Mineral Selection No. 2824, and subsequently became freehold under the old Mining Act of that date. There are two main lodes, the "Gully" lode, on Prospector's Gully, the first found in the district, and the "Eastern" lode, situated about 300 yards further up the creek, in an east-by-south direction.

The Gully Lode has been worked to a vertical depth of 550 feet, but has lain idle since 1894, the main shaft having since collapsed and become unworkable. The outcrop of the lode strikes a little east of north for a length of about 3 chains, and shows a dyke of elvan running along its eastern wall. Plans of the mine show that the lode material was associated with this elvan dyke in the lower levels, and the junction of the latter with the granite appears to have formed the line of weakness along which the mineralising agents found access from below. The official returns from this mine show a total of 1,410 tons of black tin, of a value of about £70,500 for the 515 feet of sinking. This ore was obtained from 5,148 tons of stone, showing an average of over 36 per cent. This stone was all crushed between the years 1884 and 1889. The greater proportion was obtained above the 250-feet level, after reaching which the lode became much smaller and poorer, though the stone crushed in the last three years averaged 22 per cent.

The Eastern Lode has been been worked to a vertical depth of 550 feet, and during last year was again met in a drive from the main shaft, at a depth of 700 feet. The lode formed a prominent outcrop on the surface, running north and south for about 120 feet, with a width of about 18 feet at its southern end. The outcrop terminated abruptly either way, with no sign of its continuation to north or south. The outcrop ore was removed in an open quarry going into the hill in a southerly direction. This quarry has levelled the surface formerly occupied by the outcrop ore, leaving a wall of granite on the east. To the south it terminates against another wall of barren granite. The ore was stoped out by three shafts to a depth of from 50 to 80 feet. The northernmost of these subsequently became the main shaft. At a depth of 50 feet it met a flat slide dipping to the north, which cut off the tin completely below the surface workings. The north shaft was then sunk through barren ground for 100 feet before meeting good ore again at the 150-feet level. The shaft was completed to the 200-feet level in 1884, and winding machinery erected in 1886. At the 200-feet level the shoot of ore ran for about 100 feet north of the shaft, and 25 feet south of the shaft, and was from 10 to 20 feet wide, but of very irregular cross section. It was stoped on the south side of the shaft, to which it inclined steeply as it was followed up in a wide irregular stope. The slide passed through in the shaft was again met with in this stope at a point about 80 feet south of the shaft, and about 100 feet above the level. This stope, known as the "south stope," afforded an immense quantity of rich ore. Below the 200-feet level the greater portion of the ore came from north of the shaft, which was continued on vertically to the 400-feet. At the 300-feet the shoot of ore was about 65 feet in length and 10 feet in breadth, but below this point it became much smaller, and was followed down by a winze to the 400-feet level, where it was about 70 feet in length and 10 to 12 feet in width. From the 400-feet the ore was followed down by two irregular winzes to the 450-feet level, and subsequently by another irregular winze to the 500-feet level. The ore body below the 400-feet was comparatively poor and small, and was finally abandoned in 1892. The mine remained idle, except for a little tributing in the upper stopes, till 1901, when the shaft was again bailed out and sinking continued. During last year the lode was again met with at the 700-feet level, in a drive north from the bottom of the shaft.

The official returns of ore from this mine show that 6,371 tons of stone were crushed for a yield of 1,674 tons of black tin between the years 1884 and 1891. This gives an average of 26 per cent. for all stone crushed, and a gross value of about £63,700. In addition to this, a considerable amount (perhaps 2,000 tons), was crushed in 1883, of which there is no exact record.

The ore from this mine is very coarse-grained, occurring in association with quartz and a black serpentinous mineral. The lode does not occur along any well-defined course, and shows no signs of being connected with any fault or fracture in the granite. Owing to the good standing qualities of much of the ground, very little timber has been used, and consequently a great portion of the old workings can still be examined. The ore, where richest, occurred in large lumps and veins of cassiterite associated with a clean white quartz. In many parts of the mine the lode has been left as large masses of white quartz, too poor in tin to work. This white quartz is seen to pass gradually into altered granite rock, carrying less quartz, and showing serpentinisation of some of its mineral constituents. This gives rise to a dark-black amorphous-looking rock, always regarded as lode formation by the miners. As the outside edge of the lode is approached, the alteration of the granite becomes less and less, passing rapidly, but with easily recognisable gradation into the unaltered granite. The bounding-planes of the lode formation are exceedingly irregular, giving the lode a widely differing cross section at every level. The lode formation is without doubt a result of the alteration of the granite rock by the influence of mineralising agents which have been introduced into it subsequent to its solidification.

(2.)—WATSONVILLE DISTRICT.

Watsonville township lies about 5 miles due west of Herberton, on the western fall of the main divide. It is in the drainage area of the Walsh River, which flows about 2 miles to the north of it. From the time of the first discovery of the lodes on the hills to the east and south of the town, up till the year 1896, these mines were worked with great success, the annual return from the Bischoff Mill, on the Walsh River, being about 250 tons of black tin, of an average yearly value of about £10,000. The mines were mostly worked by small parties of men, holding small areas, and working with primitive appliances. The workings generally followed down narrow shoots of ore, often in a very irregular manner, necessitating two or three handlings before the ore could be landed at the surface. It had then to be carted to the mill on the Walsh River, a distance of 2 miles from the nearest mines, over bad roads. The average value of the ore for the fifteen years from 1882 to 1896 was a little over 16 per cent. for 26,531 tons of stone. Mr. Jack visited these mines in 1883, and described 36 lodes in his report on the district. Many of these were worked continuously for some years, but the greater number were gradually abandoned as the surface deposits were worked out, and the attempts to locate the lodes at greater depths became too expensive for the means at the disposal of the miners. The rapid fall in the price of tin in 1893 materially aided the gradual abandonment of the mines. At the time of Mr. Skertchly's visit in 1895 only a very few were being worked, and they only in a desultory way. The yield of tin also fell rapidly, till, for the years 1900 to 1902, it only averaged some 30 tons annually. During last year (1903), the Bischoff mill crushed 821 tons of stone for a yield of 65 tons of tin, valued at £4,854.

At the time of the writer's visit to the field, the only work being done was the stoping of ore at about 100 feet depth in the Montgomery shaft on the top of the hill, to the west of the Great Western Mine. The ore here was being followed down as a narrow shoot with a very irregular downward course by irregular workings necessitating three handlings of the ore before it reached the surface. It consisted of altered porphyry rock, silicified and impregnated with grains of tin. There were no walls to the lode, which apparently followed no defined course, the ore merging gradually on all sides into barren rock. It was evidently being followed only by the exercise of the greatest care in observing where the rock was barren and where tin-bearing.

The ore shoots in this district were apparently narrow and very irregular, both in shape and richness, at different levels. The ore seems to have occurred in bunches, elongated generally in a more or less vertical direction, and separated from each other in the vertical line by patches of barren rock which had to be sunk through before other bunches of ore could be picked up.

Their positions seem to have been determined by the jointing of the country rock, and its alteration to lode matter by the admission of mineralising agents from below.

Mr. Jack, in his report, published a map showing the topographical features of the neighbourhood and the boundaries of the different formations. Mr. Skertchly, in his report, reproduces this map, with a little added detail, and also gives considerable information about some of the most important mines, with plans showing details of the work done up to that time. Since Mr. Skertchly's visit very little work has been done on any of these mines. The lodes occur both in the porphyry on the hill to the south of the town, and in the greywackes and slates to the east. Of the former, the Caledonia, King of the Ranges, Great Western, Stewart's T., and Chance mines were the largest producers, and of the latter the North Australian group and Federation group. The greater number of the mines on the hill to the south of the town, including the Great Western, Stewart's T., Chance, and Cuprite Mines were consolidated in 1890 into one company, and an attempt made to work them again. The main adit on Stewart's T. Mine was continued towards the Great Western Mine, but apparently without finding any important bodies of ore. This work was in abeyance at the time of my visit to the field, but I understand has been resumed again since.

(3.)—THE IRVINEBANK DISTRICT.

The township of Irvinebank lies about 8 miles west-south-west of Watsonville, on Gibb's Creek. After the erection of the battery in 1884, it became one of the chief mining centres of the tinfield, and since the starting of the Vulcan Mine in 1891 it has been the leading industrial centre. The battery now consists of 30 head of stamps, with numerous dressing appliances and smelting plant attached. The Great Southern and Red King Mines lying near together about 2 miles south of the town, furnished the great bulk of the tin for the first few years, and subsequently the Old Tornado, Comet, Adventure, Pandora, Columbia, and many other smaller mines contributed largely to the returns. In 1890 the Vulcan Mine was purchased by the present company, and since then has yielded the great bulk of the tin, aggregating for the next ten years 5,066 tons out of a total of 5,730 for the whole of this district. The remaining mines all failed to afford sufficiently large bodies of ore when sunk upon to allow of their being worked to any depth. The deepest was not prospected to more than 300 feet from the surface.

The total return of stone for the district for the six years prior to the opening up of the Vulcan Mine shows an average of 11.9 per cent. tin from about 28,000 tons of stone. The Vulcan stone shows an average of 10.9 per cent. for about 55,000 tons of stone. The great size of the ore bodies, and the richness of the ore in this lode has allowed of its being worked almost continuously to the 600-feet level, notwithstanding that the lode has been several times completely lost, and only found again by persistent prospecting at great expense.

The majority of the lodes lie within a few miles of the battery round which the township has grown up. The country is rough and hilly, and the making and up-keep of roads for carting ore are expensive items. Timber for mining is abundant.

The geological formation of the country amongst which the lodes in this neighbourhood occur, is a series of folded greywackes, quartzites, and slates. These rocks strike generally about north and south, dipping at high angles, often almost vertically. The bulk of the ore deposits occur in the coarser quartzites and greywackes. They resemble those found in the igneous rocks in the manner in which lode material merges into barren rock with no break of continuity between the two, and often in the bunchiness and irregularity of disposition of the ore. This latter character is not, perhaps, so marked or so universal. The rock fractures seem, in the cases of the sedimentary beds, to have been more continuous or more closely set together, and to have allowed of the formation of more continuous shoots of ore.

The lode material is generally a fine-grained green chloritic rock, which weathers to a rusty-red on the surface, thus giving an indication to the prospector of the presence of a lode. Under the microscope it shows a complex mixture of grains of green chlorite and colourless quartz, through which are scattered grains of magnetite and crystals of tin, often massed together in bunches or along veins. This material is evidently the result of the alteration *in situ* of the original sedimentary rock by the ascension into it of mineralising agents from below. The silicate minerals have been attacked and replaced by secondary quartz and chlorite, and the tin and magnetite, with lesser amounts of bismuth sulphide, galena, and copper pyrites have been deposited amongst them.

The Vulcan Mine.

The Vulcan Mine lies on the northern side of Gibb's Creek, about half a mile below the township of Irvinebank. The outcrop is near the eastern edge of a belt of greywacke rocks, which strike roughly north and south, and stand almost vertically. This belt of coarser-grained rocks is about 5 chains in width, and is bounded on the east and west by slates and schists.

The lode has been worked to a depth of 800 feet from a vertical shaft sunk on the edge of the greywackes, about 150 feet south-east of the outcrop of the lode, and by levels driven from the shaft at depths of about 100 feet apart.

The size and shape of the ore body vary greatly at different levels, being on an average about 40 feet in length by 20 feet in breadth, but of very irregular section. It has a general dip to the south-west at a steep angle.

The outcrop was on the eastern fall of a ridge, and was taken out by shafts sunk on the lode, and by an adit from the side of the hill about 80 feet lower down. The ore body at the outcrop measured about 38 feet in length by about 16 feet in width. The main vertical shaft was sunk from near the entrance of this adit. The shoot of ore went vertical to the adit level. It then underlay steeply to the west-north-west, following the line of strike of its greatest length, and increasing gradually in size as it was followed down. At the 100-feet level in the shaft this lode had increased to 70 feet in length by 25 feet in width. At the 200-feet level in the shaft a drive was put in to catch the shoot of ore underneath the eastern end of the stope at the 100-feet, but failed to get any tin. By the time it had been stoped down to the 180-feet level in the shaft, the ore body had opened out to 85 feet in length by 30 feet in width. It had produced 2,357 tons of black tin, valued at £65,784, from some 15,020 tons of stone, within 260 feet of the outcrop, and had paid £28,013 6s. 8d. in dividends.

Owing to the splendid standing quality of the ground in which this lode occurs, the stope from which this ore was taken remains as an enormous cavern, 85 feet in length by 30 feet in width at its base, and tapering up from the 180-feet level to the adit level 180-feet above, where the roof has been timbered over to prevent accidents from falling stones.

As the ore was carried down from about the 180-feet level, it gradually gave place to barren rock. The splendid ore body worked above gave place to a few small veins of ore leading down in different directions.

One small vein was followed down on the western end of the shoot by a winze dipping steeply to the south-west. This vein gradually opened out till at the 280-feet level—*i.e.*, 100 feet lower down, it measured 38 feet in length by 26 feet in width. Below this point it decreased again rapidly, and "petered out" entirely at the 320-feet level. A second narrow vein leading down from the north-eastern side of the 180-feet level was followed down by a winze, dipping at about 45 degrees to the north-east, at a depth of about 100 feet below the floor of the big stope; this opened out in another large body of ore which has since been worked in the adjoining Tornado Mine.

An attempt was made to pick up the lode that "petered out" at the 320-feet level in the Vulcan Mine by a drive from the shaft at the 400-feet level. This drive failed to find tin under the stopes above, and a great deal of prospecting by means of drives and crosscuts in all directions was carried out before tin was again found. Meanwhile, the ore was supposed to have completely "duffered out."

By a lucky inspiration, a crosscut was put in in a south-westerly direction, at a point where there had been a strong inrush of water in driving the level, along an open seam in the country rock, the manager suspecting that the flooding of water had some connection with the existence of an ore body in that direction. Tin was first found 60 feet west of where the lode was lost at the higher level. This prospect soon opened out into a body of ore 40 feet in length by 16 feet in width. On being stoped upwards it rapidly contracted, and 40 feet above the level had completely "petered out."

The ore body at the 400-feet level had thus apparently shifted bodily 60 feet to the south-west, with no aparent connection between the two portions, except the open seam along which the circulation of the water was taking place.

Below the 400-feet level the ore body has been stoped underhand to the 550-feet level, and has turned out an enormous quantity of ore. At the 500-feet level the still open stope measured 150 feet in length by 25 feet in width, and forms a cavern extending up to above the 400-feet level, and completely open. At the 550-feet level two horses of barren rock have come in, dividing the shoot into three ore bodies. The centre body has been followed down by a winze to the 600-feet level from the shaft, down which the ore is passed, and around which it is being stoped.

At the 600-feet level it was about 50 feet in length by 30 feet in width, and has been stoped downward for another 40 feet, when it completely disappeared in the country rock. The western shoot of ore from the big stope was followed as a narrow pipe to the 750-feet level, where it was met by a prospecting drive from the shaft, which has, however, failed to pick up any large bodies of ore. A small body met with under the eastern end of the big stope, on being stoped up for a short distance, was lost in the rising, which was broken through into the main central lode at the 550-feet. The shaft is now being sunk to the 900-feet level, with the object of prospecting for a continuation of the ore bodies at that depth.

Since its purchase by the present company this mine has turned out, up to the end of 1903, 5,964 tons of black tin, of a value of some £220,000, from above a depth of 800 feet. For the first five years during which the large ore body, from the surface down to the 180-feet level in the shaft, or 260 feet below the outcrop, was being worked, the ore averaged about 15 per cent. of black

tin for about 17,000 tons of stone. Since then it has averaged about 9 per cent. of tin for about 38,000 tons of stone. Some of this latter stone has, however, been taken from that left in the upper stopes as too poor to be profitable.

The Tornado Mine.

The ore body worked in the Tornado Mine is apparently an offshoot of that worked in the Vulcan Mine. The vein of ore found dipping off to the north-east at the 200-feet level in the latter mine, on being followed down by means of a winze, opened out into a body of ore some 100 feet in length by 20 feet in width, and 40 feet in height. This ore has all been removed and crushed, leaving an immense cavern with walls, roof, and floor of barren greywacke rock. The Mines Department records do not show the amount of ore that has been taken out of this hole, but it must have been very considerable. Below it no tin has as yet been found, though at 100 feet below a level has been driven right under the ore body, and crosscuts have been put in right and left, at different points, in attempts to again pick up the lode.

During 1901 and 1902 the amount of stone crushed was 5,212 tons for a return of 425 tons of black tin, worth £18,490.

The Great Southern Mine.

This mine lies about 2 miles south of Irvinebank. The workings extend along the outcrop of a belt of greywacke striking about north and south, and dipping to the west. On either side are fine-grained compact slates. The main outcrop, on which the main shaft has been sunk to a vertical depth of 390 feet, was taken out on the surface as a huge quarry from which a great quantity of ore was obtained. The shaft followed this body down in the underlie, dipping north-west at about 60 degree from the horizontal. At the 130-feet the lode was lost in the shaft, which passed into the underlying slates. The mine lay deserted for many years, but latterly the shaft has been again sunk to the 290-feet level, and crosscuts to the north-west at the 190 and 290-feet levels found the lode at about 30 feet from the shaft, and a large amount of ore has been stoped out between these two levels. A subsequent drive from the 350-feet level found a little ore, which was followed down for another 40 feet, but proving too poor to be payable the mine was closed down in September of this year.

Since 1901 2,359 tons of stone have been crushed from these lower levels for a return of 110 tons 18 cwt. of tin, valued at £6,268.

About 150 feet north of these workings another shoot of ore, known as No. 3 workings, was worked down to the 130-feet level, and connected by a level with the main workings, and seems to have afforded large bodies of ore, judging from the open stopes still left.

Numerous shallow workings extend north from the Great Southern shaft to the Red King Mine, some 14 chains off. These workings lie along a line roughly parallel with the strike of the greywacke rocks in which they occur. At the

Red King Mine

the lode has been worked for a length of about 200 feet down to the lowest level at which an adit could be brought in from the base of the hill. Below this level the lode appears to have been lost. The old workings show that the course of this lode was here more regular in character than is usual in this district. They can be followed between the still standing walls of the lode,

which dip a little to the west, and are in places 10 or 12 feet apart, and show evidence that the lode material was almost entirely confined to the space between them. There are no official records of the amount or value of the ore crushed.

The Adventure Mine.

The Adventure Mine lies about 3 miles due south from Mount Albion, and about the same distance south-west of Irvinebank. The lode outcrops along the top of a ridge striking in a north-westerly direction, and dipping at about 60 degrees to the south-west. It has been worked down to a depth of about 150 feet below the top of the ridge by means of two shafts and an adit at the lower levels. The lode material is a soft white kaolin binding fragments of rock, and occurs between two well-defined walls which run in a regular course, and are apparently the result of faulting of the country rock. There were apparently two shoots of rich ore, the north-eastern one of which was taken out for a length of about 60 feet, and to a depth of about 240 feet, where it was met by the tunnel. The south-eastern shoot was worked down to about the 200-feet level. There is no official record of the amount of stone crushed or tin obtained from this mine.

The Pandora Mine.

At this mine a body of ore was found outcropping on the southern slope of a hill some 3 miles north of the township, in greywacke rock, close to its junction with slates, both dipping at an angle of about 45 degrees in the direction of the slope of the hill, with the slates overlying the greywackes. The slope of the hill was about 60 degrees, and the ore was worked down by means of shafts and an adit from the side of the hill as it followed the junction-line between the two rocks, to a depth of about 120 feet from the outcrop. The shoot of ore ran for about 100 feet from the contact of the shales, and is said to have given 20 tons of 10 per cent. ore in the last 60 feet of sinking.

None of the mines in this neighbourhood, except the Vulcan and Great Southern, were being worked at the time of the writer's visit, and as there are no official records of the individual returns of the various mines, it is difficult to form any opinion as to their value. The fact, however, that the average value of the ore raised was nearly 12 per cent. shows that although a great many of the shoots of ore were comparatively small, they must have been very remunerative in the shallower levels.

(4.)—EUREKA CREEK DISTRICT.

These mines were worked during the years 1888 to 1893, and the stone crushed at a battery erected on Eureka Creek, a little above the Ivanhoe and Eclipse Mines. During the first three years 3,546 tons of stone were crushed for a return of 392 tons of black tin, of a value of about £20,000, and an average value of about 11 per cent. tin. There are no records of the amounts crushed in 1891 and 1892, but apparently there was very little ore raised. The mill was hung up during the greater part of 1891, and the mines are not referred to in the Warden's report from the field in 1892. In 1893, 377 tons were crushed, and yielded 54 tons of black tin, an average of 14 per cent. By this time the best of the easily-obtained ore had been worked out, and the mines proved unpayable at the low prices then obtainable for tin without the introduction of capital for further development. The mill was removed to another portion of the field in the latter part of 1893, and the mines were practically abandoned.

In 1899 a number of these lodes were taken up again by the Stannary Hills Company, and a 20-head battery was erected on the Walsh River, 5 miles to the east. The mines were connected by a 2-feet gauge tramline with the battery, and also with the Chillagoe Railway line, at its crossing of Eureka Creek, 14 miles further down the creek. The line was completed in 1902, and the battery commenced crushing in August, 1903.

The Stannary Hills Company's Mines.

The mines being exploited by the Stannary Hills Company lie in a series of greywackes and slates near the head of Eureka Creek. These sedimentary rocks cover an area about 3 miles long and 1 mile broad, and are surrounded on all sides by granitic rocks. The ore deposits are almost entirely confined to the coarser beds of the series. The most important lodes lie along the outcrop of a belt of felspathic greywacke standing vertically between beds of soft fissile slates. The belt of greywackes is about 800 feet in thickness, and strikes in a north-westerly direction across Eureka Creek. The Ivanhoe, Eclipse, Monarch, Extended, and Black Rock Mines lie along this belt over a length of about a mile. They are the only ones that have been worked by the present company. Further south are the Hornet's Nest group, and other lodes, all apparently on the same line of outcrop of greywacke rocks.

The Ivanhoe Mine lies on the southern bank of Eureka Creek, the outcrop of the lode being about 100 feet above the creek bed. The ore body had been stoped out down to the level of the creek by means of tunnels driven in from the bank. These workings left a pipe-like excavation of roughly oval section, measuring from 15 feet by 9 feet in its narowest portions to 20 feet by 15 feet in its widest. A shaft was then sunk from the surface, from a little north of the ore body to a depth of about 200 feet, and the ore worked out to that depth. The ore from this working is said to have given a return of about 13 per cent. of black tin.

The memorandum-book of the Bischoff-Herberton Tin Mining Company showed that 835 tons of ore were crushed from these workings for a return of 61¼ tons of black tin, showing an average of 7 per cent. Other old workings are found along the same belt of country, the most important being the Black Rock workings, lying some 14 chains north of the Extended, and the Eclipse workings, some 8 chains east from the Ivanhoe.

At the 290-feet level the ore body was met with 50 feet north from the shaft, and was being driven on at the time of my visit. It was then proved for 18 feet in length, and was estimated to show 2,000 tons of 9 per cent. ore above this level.

On the Extended workings, the Kitchener shaft had been sunk vertically a depth of 268 feet, and joined with a tunnel 660 feet in length, coming in from the west from the bank of the Eureka Creek. Ore was found in this mine at the 105-feet level, 18 feet south of tho shaft, and for a distance of 15 feet. Its width was not proved. It was estimated to be worth 9 per cent. The ore body had not been found at the 180-feet level.

The Extended shaft, about 130 feet north-west of the Kitchener shaft, had been sunk vertically to a depth of 186 feet. The ore body had been found in a drive about 80 feet north from the 120-feet level, and a winze sunk on it for 60 feet. At 30 feet down it was estimated to be 70 feet long by 40 feet in width. The 186-feet level had not reached the ore body.

The ore bodies in this district resemble in character those found at Irvinebank. Their extreme irregularity, both of shape and in value, when traced from point to point, makes the estimation of quantities of ore

developed, or likely to be developed by further working, a matter of the greatest difficulty, and makes the opening up of fresh ore reserves well ahead of the requirements of the battery a *sine qua non* of economic mining here as elsewhere in this district.

The proper opening up and proving of their ore reserves by the Stannary Hills Company had, up to the time of the writer's visit, been subordinated to the construction of the tramline and the erection of a battery. By the time that the battery was ready to commence crushing, the company's workings, described above, were quite inadequate to keep it fully supplied with ore, and the company was hampered by lack of funds for further development. Since commencing crushing in August up till the end of the year, the mill put through 5,660 tons of stone for a return of 210 tons of black tin, showing an average of 3.71 per cent. This return is most disappointing, considering the high assays reported from time to time, and the capacity of the mill, which should be capable of putting through over 3,500 tons a month.

(5.)—THE KOORBOORA DISTRICT.

These mines were reported on by Dr. Jack in 1890. At that time they were being prospected by Messrs. John Moffatt and Co., of Irvinebank, the ore being packed into Irvinebank, a distance of 30 miles, to be crushed. In 1899 a mill was erected near the Shakespeare Mine, and crushing has been fairly continuous since the beginning of 1900. The Shakespeare Mine has contributed the bulk of this ore, especially during later years.

The ore deposits occur in a series of hardened sandstones and mudstones.

The shoots of ore in this district appear to be small, but the average value of the ore is fairly high. They are, however, very bunchy, and hard to follow.

The Shakespeare Mine.

The main ore body was taken out to the 60-feet level for 50 feet in length by about 8 feet in width. This ore body dipped to the west, and was met at the 100-feet level by a crosscut east from the vertical shaft, 20 feet in length. At this point the ore body was stoped out for 30 feet in length by 14 feet in width and 20 feet in height, but above that, to the 60-feet level, it was barren of tin, or too poor to work.

The crosscut at the 200-feet level met a large body of low grade ore, 20 feet in width, at 80 feet east of the shaft, the lode having apparently turned over to the east. On the eastern wall a seam of good tin was ready for stoping.

A second shaft, 215 feet south of these workings, passed through a shoot of ore which was taken out for about 20 feet in length and 5 feet in width, down to the 60-feet level. Below this a drive north from 70 feet depth in the shaft passed through the same chlorite formation, but here it was barren of tin.

The Portia Shaft.

The Portia shaft is about 300 yards further south, and followed down a roughly circular-shaped ore body to the 100-feet level. The lode was being stoped above that level.

The battery here has been kept going by numerous small mines in the neighbourhood, none of which have as yet developed any very important bodies of ore. Since the completion of the battery in 1900 to the end of 1903, 11,598 tons of stone have been crushed for a yield of 341½ tons of black tin, valued at £19,416. This gives an average value of £1 13s. 6d. per ton for all ore crushed.

(6.)—NEWELLTON DISTRICT.

The Launcelot Mine.

This mine was discovered about 1895 by Harrod Brothers. It was visited by S. B. J. Skertchly in that year, when three shafts had been sunk on the lode, along a length of about 100 feet, and to depths of 35 feet, 40 feet, and 53 feet. The lode had also been traced for about 200 feet north-west of the workings by two shallow shafts. In 1899 the mine passed into the hands of a German company. The ore shoot on which the three shafts described by Mr. Skertchly were sunk, has been followed down by sinking the two extreme shafts to the 150-feet level. These have been connected at that level, and the level continued along the lode for 200 feet north-west. The ore shoot at the 150-feet level has proved continuous for a length of about 210 feet north of the No. 1 shaft. It was being stoped up from this level at the time of my visit, and had been carried up a height of about 45 feet. At the north-western end of this shoot—*i.e.*, 210 feet from the No. 1 shaft, the lode pinched out and the formation took a bend to the west. It was driven on to a distance of 270 feet, where the lode had been followed down from the surface by an inclined shaft. In the stoped-out ground the reef has averaged about 3 feet in width, and has returned nearly 12 per cent. over a length of about 200 feet. Up to the end of 1903 the present company had crushed 4,190 tons of stone for a return of 494 tons of tin, valued at £28,234, or an average value of £6 14s. 7d. per ton.

The lode occurs in a series of quartz and clay schists, and strikes parallel to the bedding. The gangue is siliceous, and the mineral is evenly distributed through it, mixed with a considerable amount of copper pyrites and metallic bismuth. Unlike the majority of the lodes in this district, this lode runs with a fairly regular course between well-defined walls, the lode material, or gangue, being separated by well-marked planes of division from the barren country rock on either side. The present company have continued the No. 2 shaft to the 200-feet level, and are developing the lode at that depth.

Other Lodes near Newellton.

South of the Launcelot Mine are several other lodes which have as yet received very little attention, but have lately been secured by the Launcelot Company, and will shortly be developed. Of these the most important are the Freehold lode, about half a mile further south, and the Magnum Bonum lode, about 3 miles to the south.

(7.)—COOLGARRA DISTRICT.

These lodes were prospected in the early years of the field, parcels of picked ore being bagged and sent away to distant batteries. In 1885 a battery was erected on Return Creek, and during the next four years 3,845 tons of stone were crushed for a yield of 272 tons of tin, an average of 7 per cent. The mines remained unworked from 1889 till 1899, when the Coolgarra Company was formed to take over most of the mines in the neighbourhood, and the erection of a new 10-head battery was put in hand. Crushing commenced in January, 1901, and proceeded continuously till September, 1903.

The lodes at Coolgarra lie in the sedimentary rocks close to their contact with granite porphyry. The main producers since the present company began work have been the Alhambra Nos. 1 and 2. At the time of the writer's visit the Alhambra No. 2 was the only mine being worked, the remaining mines having all been closed down.

The Alhambra No. 2 is situated on the western face of a hill immediately to the east of the township, and is connected by a tramline with the mill on a

branch of Return Creek, about half a mile further east. The ore occurs as irregular shoots in a coarse greywacke, similar to that found at Irvinebank and Stannary Hills.

The old workings followed the best of the ore down to the 110-feet level, and a tunnel, driven in a north-north-east direction from the side of the hill, met the bottom of the shaft. At this point the present company took out a large body of ore. A drive put in to the north-west met another large body in 40 feet, which was worked out as a large open cavern 40 feet in length by 20 feet across, extending to the surface, and which furnished the greater portion of the crushings in 1902 and 1903.

To meet this shoot of ore at a greater depth No. 3 shaft was sunk about 125 feet north-west of the old shaft, but after 40 feet of stoping underhand the No. 2 shoot gave out altogether, and was replaced by greywacke rock.

No. 3 shaft was sunk to the 255-feet level, and a crosscut to the south-east, towards the No. 2 shoot, met a third shoot of ore within a few feet of the shaft. On stoping up, this body of ore became too poor to work, but was carried down and met again in sinking the shaft another 100 feet. The ore body was being risen on from the 355-feet level at the time of my visit, but proved too poor to be profitably worked, and the mine was closed down in September. During 1903 this mine crushed 7,726 tons of stone for 127 tons of black tin, valued at £5,595, or an average of under 14s. per ton.

During 1902 the amount crushed was 11,158 tons for 257 tons of black tin, valued at £13,800, or an average of £1 4s. 8d. per ton. About 9,019 tons of this came from the Alhambra No. 2 Mine, the remainder being from the Alhambra No. 1, or small lots from some dozen or so other lodes scattered about the district.

The Alhambra No. 1 is a lode of the same character, lying on the same belt of rocks, north of the No. 2. It furnished about 1,090 tons of ore during 1902, but was then abandoned.

The remaining mines of the district afforded small parcels of somewhat richer ore than that found on the Alhambra Hill, but none of them have been worked to any depth.

(8.)—THE SMITH'S CREEK MINE.

This mine was discovered during the latter part of 1901. It lies about 7 miles north-west of Mount Garnet township, and 1 mile north of the railway line to that place.

The country rock is a grey biotite granite, which shows evidence of weathering at 100 feet below the surface in the main shaft. The main ore body has been taken out at the 100-feet level for 78 feet in length by 35 feet in width. It has been worked from a vertical shaft sunk a few feet south-west of the main shoot of ore, and by a main drive which runs parallel to the course of the lode at the 100-feet level in a south-easterly direction. Crosscuts were driven at distances of 60 feet and 110 feet south-east of the shaft in a north-easterly direction to intersect the lode.

At a point 182 feet south-east of the shaft the level takes a bend to the east and meets another ore body, which at this level was 31 feet in length by 16 feet in width. This body had been followed down by an inclined shaft from the outcrop.

The main shoot was being worked by overhand stoping from the 100-feet level up, at the time of the writer's visit, and has since been all taken out to the surface. On sinking a winze on this ore body at the 100-feet level the ore

passed into granite rock, and the shares immediately collapsed. The company have since stoped out all the ore above the 100-feet level, and have no reserves of ore developed below. They have since commenced to sink their shaft and to crosscut at different levels, with a view of prospecting for further deposits of ore. Meanwhile, the mill is idle till further supplies can be found.

The ore in this mine occurs as coarse grains of tin through the altered granite rock. In all, some 18,764 tons of stone have passed through the mill for a yield of 585 tons of black tin, valued at £41,093. A considerable portion of this tin was obtained from the sluicing and subsequent crushing of the surface sheddings from the lode. As there is no separate return of the amount so derived the returns are vitiated as an index of the value of the ore mined. The above figures give an average of 3.12 per cent., but the actual value of the lode material must have been considerably less.

The history of the sudden collapse of this mine in public estimation is an example of the effects of not attempting to keep development of fresh ore reserves well ahead of the extraction of that already in sight. The evil effects in this case have been somewhat mitigated by the setting aside of a small reserve in cash, which is now available for further prospecting.

(9.)—CALIFORNIA CREEK AND REID'S CREEK LODES.

A battery was erected on California Creek, just below the present crossing of the railway line to Mount Garnet, in 1888, but, according to the warden's report for the following year, the crushings were too poor to be profitable, and the mines were closed down. The lodes lie about a quarter of a mile to the west, and were connected with the battery by tramline. They occur near the eastern edge of a patch of greywacke rocks, close to their junction with the granite, and the remains of several old shafts and poppet heads are still to be seen. There are no records of the crushings from these lodes. At Reid's Creek the lodes were in granite.

The Village Blacksmith Lode.

The Village Blacksmith lode outcropped on the northern face of a hill above Reid's Creek. Two tunnels were put in along the lode, the eastern at a slightly lower level than the western, and the ground between has been all stoped out. The tunnels are about 40 feet apart, and go in for about 50 feet. The ore in this lode lay along a flat seam in the granite, apparently a contraction fracture caused by the shrinking of the granite during cooling. It was cut off along the line of the eastern tunnel by a vertical joint plane, but tin is still showing on the other side of this break, and should be worth prospecting. The ore occurs as an altered form of the granite, splashed through with crystalline tin. It is said to have been very rich.

Within the last year several promising-looking deposits have been found in this neighbourhood, but at the time of the writer's visit they were in too undeveloped a state to allow of any opinion being formed as to their value.

By Authority: George Arthur Vaughan, Government Printer, William street, Brisbane.

Queensland.

DEPARTMENT OF MINES.

GEOLOGICAL SURVEY OF QUEENSLAND.
Publication No. 193.

REPORT.

WET PROCESSES OF COPPER EXTRACTION,

With Special Reference to Queensland Ores.

By LIONEL C. BALL, B.E.,
ASSISTANT GOVERNMENT GEOLOGIST.

BRISBANE
BY AUTHORITY: GEORGE ARTHUR VAUGHAN, GOVERNMENT PRINTER, WILLIAM STREET.
1904

LETTER OF TRANSMITTAL.

Geological Survey Office,
Brisbane, 27th April, 1904.

SIR,—I have the honour to forward for publication a Report by Mr. Ball entitled "Notes on Wet Processes of Copper Extraction, with Special Reference to Queensland Ores."

The paper contains much useful information compiled from various publications, and, although it does not pretend to be exhaustive by any means, it will be a general guide to the wet processes of copper extraction so far as they may be applied to Queensland.

I very much desired a bibliography of the subject to be incorporated with the paper, not only of those works consulted, but those which were not available to us and those which time did not permit being consulted; but, as this would cause some delay in its issue, it was deemed advisable to leave the bibliography for some future publication.

A critical discussion of its contents may be anticipated after publication; but due allowance must be made of the fact that the compilation has of necessity been hurriedly performed, and that such work is not quite on the lines laid down for the work of a geological surveyor.

I have, &c.,

B. DUNSTAN,
Acting Government Geologist.

The Under Secretary for Mines.

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WET PROCESSES OF COPPER EXTRACTION.

WITH SPECIAL REFERENCE TO QUEENSLAND ORES.

1.—Introduction.

Renewed interest has of late been taken in the copper ores of the Cloncurry district, and inquiries have been made as to the best method of treating them. Wet processes have been brought under notice by miners having during the past couple of years treated the cupriferous waters of the Dee River below the Mount Morgan works (where copper is now saved by the company) and by trials made with ores from the Chillagoe district. Consequently, brief descriptions of the different wet processes which are practised in other parts of the world, and which are most likely to be suitable for Queensland ores, have been prepared.

In the following pages, after mentioning some of the Queensland deposits available for wet processes, will be given in detail—the various copper ores likely to be treated, the preparation necessary for the various ores, and the processes for dissolving the copper salts, followed by the methods of precipitating the copper or its salts, together with brief notes on its subsequent treatment. In no case is a single process fully described under one heading, and therefore in a summary all the processes are either briefly described or graphically represented. The electrolytic methods of extracting copper are not referred to in detail, as the cost of installation and the absence of water power seem to prohibit their use in Queensland.

A few details on plant, construction, treatment, and costs are given under the concluding remarks, but these are matters that will have to be determined in each particular case by the metallurgist in charge. Very little has been written concerning the cost of construction, and the items will therefore require to be determined when the amount of ore to be treated and the process to be employed are decided on.

In compiling the following notes references have been made to the following publications:—Schnabel and Louis' "Handbook of Metallurgy," the volumes of the "Mineral Industry," Eissler's "Hydro-metallurgy of Copper," Phillips and Bauerman's "Elements of Metallurgy," "The Journal of the Society of Chemical Industry," and "The Engineering and Mining Journal."

1.—HISTORY.

The hydro-metallurgical treatment of copper ores, first employed in connection with the recovery of copper by precipitation from mine waters, has been practised for centuries, but only came into prominence in the latter part of the nineteenth century. There are now numerous processes differing in detail, but alike in broad principle—viz., rendering the copper in the ore suitable for solution (by oxidising or chloridising), dissolving the copper salts in suitable solvents (sulphuric acid, hydrochloric acid, ferrous chloride, &c.), precipitating the copper (by metallic iron, sulphuretted hydrogen, milk of lime, &c.), reducing the precipitate to metallic copper, and refining the same (in the dry way).

At Rio Tinto, Spain, where leaching processes have been most fully developed, natural oxidation was first employed; then heap roasting; and now lixiviation with brines is practised for the poorer ores, while the richer ores are smelted.

2.—APPLICABILITY.

(a) General.

Wet processes are employed for—

(i.) Very poor ores and the by-products (containing in exceptional cases as little as ½ to 1 per cent. copper), treated or obtained in connection with the manufacture of sulphuric acid and iron;

(ii.) Poorer siliceous copper ores, free from lime, magnesia, ferrous oxide, and manganese.

They are specially applicable for pyritic ores so low in copper that they could not be profitably smelted either directly or after roasting, but they are not suited to pyritous ores high in copper, which therefore go to the smelter. Wet processes have been used for the tailings obtained in the mechanical concentration of ores, but it is considered better, if leaching is to be used at all, to leach the whole of the ore without any concentration. Mr. Peters, one of the greatest authorities on copper smelting, places the matters thus[1]:—

> The slow Rio Tinto method of leaching is the most favourable of the processes for treating low grade siliceous ores where the magnitude of the ore bodies and the financial resources permit of its application. An intimate knowledge of local conditions and costs, wide technical experience with modern lixiviation plants and long and careful experiments on an extensive scale on the ore to be treated can alone decide the method to be chosen in any case. The only definite rule given is to crush the ore dry and roast it before lixiviation.

Mr. Peters, however, in the above article, apparently overlooks the new processes of Neill and Van Arsdale, which have every likelihood of coming into extensive use.

The product of most of the wet processes is simply an impure metal, and in their case the treatment would really be equivalent to a concentration. In certain other cases (notably Neill's) the product is an almost pure copper.

(b) Available Deposits in Queensland.

The wet methods of extraction appear to be specially applicable to the ores of many localities in this State, of which the following are instances:—

Cloncurry.[2]—The great obstacle to smelting at Cloncurry is the absence of a coke fuel, and the want of a railway to the coast has prevented the exportation of any but the very richest ores.

The deposits lie in various directions, from 1 to 80 miles distant from the township, necessitating separate treatment works for each group. They vary in width from 10 feet to 50 feet. At Hampden Mine is a belt of cupriferous slates 200 feet wide and 40 chains long. The lengths of the bodies have not yet been determined, and Mr. Cameron considers much additional prospecting necessary. The surface ores are mixtures of carbonates and oxides in a siliceous

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[1] "Treatment of Low Grade Siliceous Ores." By Ed. D. Peters, in Min. Ind., Vol. XI.; also in "Engineering and Mining Journal."

[2] Reports on the Geological Features of Part of the District to be traversed by the proposed Transcontinental Railway. By Robert L. Jack, Bris. By Auth.: 1885. G.S.Q. Publication No. 196.

[2] Recent Developments in the Copper Mining Industry in the Cloncurry District. By Walter E. Cameron, B.A., Bris. By Auth.: 1900. G.S.Q. Publication No. 153.

gangue, and therefore specially suitable for wet treatment, and by the time they have been exhausted sufficient modifications will have been introduced into the plant for the sulphides to be treated.

Timber is not very abundant over the district as a whole, but there seems to be sufficient for roasting purposes.

Chillagoe.[3]—The surface ores of this large district are oxides and carbonates in a ferruginous matrix, and they and the poorer sulphides would probably give good results with wet processes. In fact, tests have already been made by the directors of Tartana, Limited, proving that the copper in their ore may be leached without crushing smaller than three inches diameter.

Watsonville.[4]—In the North Australian Mine copper is developed somewhat extensively in slates.

Kangaroo Hills.[5]—The feature of the copper ore is the high silver contents —10 oz. silver per unit copper. Deposits up to 12 feet of carbonates and oxides in a siliceous matrix (Mount Thekla) are found, passing in depth into copper, lead, and zinc sulphides.

Moonmera.[6]—A deposit of breccia, with distributed carbonates, sulphide, and native copper, several feet wide. The mine is convenient to railway.

Mount Morgan.—At Mount Morgan the iron pyrite of the upper levels is becoming cupriferous in the lower workings, and, after treatment by chlorination for gold, the copper is now being precipitated. There is really a possibility of the great gold mine yet producing large quantities of low-grade copper ore, the metal in which may be saved by wet processes by modifications in the present plant and working.

The copper deposits at *Mount Perry*[7] and *Peak Downs*, owing to their comparative smallness and richness, are not specially available for wet treatment, but are more suitable for smelting.

Many Peaks.—The Many Peaks ores are in many points similar to those of Rio Tinto. The sulphides are massive and low in grade. The copper is readily leached out without the necessity of roasting, and without decomposition of the pyrite. The Many Peaks deposits seem to be somewhat bunchy, varying from a few feet up to ten feet in thickness; while the copper contents are about 4½ per cent.[8]

Glassford Creek[9].—The Glassford Creek deposits are low in grade, but magnetic separation followed by smelting should give the best results. It would not be possible to roast the ores as mined without a ruinous expenditure of fuel, and the ores are not suitable for leaching.

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[3] Op. cit. G.S.Q. Publication No. 167.

[4] Tin Mines of Watsonville, &c. By Sydney B. J. Skertchly, Bris. By Auth.: 1897. G.S.Q. Publication No. 119.

[5] Kangaroo Hills Mineral Field. By Walter E. Cameron, B.A., Bris. By Auth.: 1901. G.S.Q. Publication No. 167.

[6] Annual Report for year 1898 of B. Dunstan. G.S.Q. Publication No. 143.

[7] Since the above was written, it has been found that a wet process is now in operation at Mount Perry for the treatment of a certain class of ore—the poorer siliceous portion, which is obtained owing to the impossibility, because of the narrowness of the veins, of mining the ore free from country rock.

[8] Annual Progress Report. W. H. Rands, 1899. G.S.Q. Publication No. 150.

[9] Report on Certain Iron Ore, Manganese Ore, and Limestone Deposits in the Central and Southern Districts of Queensland. By L.C.B., Bris. By Auth.: 1904. G.S.Q. Publication No. 194.

Silver Queen, Severn River.[1]—Bunches up to twenty feet in width of low-grade and very siliceous copper lead zinc ore. An attempt is now being made to mechanically concentrate the ore, which contains: copper, 1.26 per cent.; lead, 7 per cent.; zinc, 8.8 per cent.; silver, 17 oz. 12 dwt. per ton; and gold, 16 gr. per ton. The Hunt and Douglas Process (*see* under "Solution") seems to be the most promising process for this ore.

3.—COPPER ORES.

The ores suitable for treatment by hydro-metallurgical methods may be arranged under four heads:—

(A.) *Oxides.*—These occur in the weathered part of copper deposits, more especially in the zone of enrichment near the water level. Two forms occur in nature—(*a*) *Cuprite* or Red Oxide (Cu_2O), when pure containing 88.8 per cent. of copper; and (*b*) *Tenorite*, Melaconite, or Black Oxide (CuO), containing 79.85 per cent. copper.

(B.) *Carbonates.*—Carbonates are the chief copper minerals in the portions of ore deposits above water level. The two forms are:—(*a*) *Malachite*, or green carbonate ($CuCO_3.CuH_2O_2$), containing 57 per cent. copper; and (*b*) *Azurite*, or blue carbonate ($2CuCO_3.CuH_2O_2$), containing 55 per cent. copper.

(C.) *Chloride* (or Oxychloride).—This mineral occurs sometimes in considerable quantity in the weathered part of ore bodies. (*a*) *Atacamite* ($CuCl_2.CuO.3H_2O$) contains 59.4 per cent. copper.

(D.) *Sulphate.*—Sulphate is a common decomposition product in copper mines below the water level, and, owing to its easy solubility, is usually found in the drainage water from mines. The natural mineral is *Chalcanthite* ($CuSO_4.5H_2O$), containing 25.4 per cent. copper.

(E.) *Sulphides.*—Practically all copper exists below water level in the form of sulphides. The sulphides are by far the most important, though as a rule much poorer in copper than the oxidised ores. The minerals are: (*a*) *Chalcocite* or Copper Glance (Cu_2S), containing 80 per cent. copper; (*b*) *Covellite* (CuS), containing 66 per cent. copper; (*c*) *Bornite* or Erubescite ($3Cu_2S.Fe_2S_3$), containing 55.6 per cent. copper; and (*d*) *Chalcopyrite*, or Copper Pyrite ($CuFeS_2$), containing 34.4 per cent. copper. The last is the most common and abundant, the others being chiefly secondary products, causing enrichment, but not as a rule of any extent. It usually occurs with pyrite (FeS_2), so that the ore as mined may contain far below 34 per cent. copper, and may sometimes be really only coppery iron pyrite.

II.—Preparation of the Ore for Solution.

A.—OXIDES.

Except in the Hunt and Douglas Process, in which it is necessary to oxidise the cuprous oxide to cupric oxide by moistening and exposing to the atmosphere, preliminary preparation is not absolutely required if the ore contain no sulphides; but, as already mentioned, it is held to be advisable to roast the ore in all cases, to render it pervious to solutions, even if it does not actually need the roast for chemical reasons.

[1] Notes on Tin, Copper, and Silver Mining in the Stanthorpe District. By L.C.B.. Bris. By Auth.: 1904. G.S.Q. Publication No. 191

B.—CARBONATES.

Usually no preliminary treatment is given beyond roasting (necessary in the Hunt and Douglas Process, where, if CO_2 is not previously driven off, it causes loss by effervescence during treatment). But the following modification of sulphuric acid leaching comes under "Preparation."

Ex.: At Stadtberge, in Westphalia, an ore consisting of azurite and malachite in quartzose schist (containing a half to two per cent. copper) after crushing was treated for eight or ten days with a mixture of sulphur dioxide, nitrous oxides, and water vapours, in a brickwork tank with a false bottom of fire brick, and having a capacity of 65 tons ore.

C.—CHLORIDE.

The chloride needs no preparation.

D.—SULPHATE.

Being soluble in water, the sulphate is treated direct.

E.—SULPHIDES.

Being imperfectly and very slowly soluble in acids or ferric sulphate, sulphides are converted into: Oxide, sulphate, sulphite, or chloride.

1. Conversion into Oxide.

Acid (ferrous chloride, &c.) being required for its solution, the oxide is only very exceptionally produced intentionally.

(i.) *By Roasting.*

In the New Hunt and Douglas Process a preliminary roast is necessary for sulphides, and the temperature of the roast must be carefully regulated, for if too high the oxides produced would not be attacked, and if too low sulphate is formed, and increases the consumption of iron during precipitation.

Ex.: At Ore Knob, North Carolina, U.S.A., the ore is roasted in three hearthed reverberatories producing a cinder containing 7.75 per cent. CuO and 4.15 per cent. $CuSO_4$.

2. Conversion into Sulphate.

One of the four following methods may be employed:—

(i.) *Atmospheric Oxidation.*

Natural weathering can be employed only for easily decomposed ores, owing to the length of time required to render the whole, or even the greater part, of the copper soluble. It has been stated that for this method to succeed the copper must be present in the ore as chalcocite (in which form it occurs in the Rio Tinto pyrite), oxidation in the case of covellite being slow, and in the case of chalcopyrite practically absent.[1] The method is the cheapest of all as far as the treatment itself goes, but the length of time required, the large capital locked up, the imperfect extraction, and the uncertain action of new ores, even when they can be found in sufficient quantity, have prevented the extension of its use. It has been proposed to employ the method at Many Peaks, in the Gladstone district. The ore here is a dense low-grade sulphide from which the copper is readily leached without decomposition of the iron sulphide.

Ex: At Rio Tinto, in the Province of Huelva, Spain, atmospheric oxidation without roasting is employed. The ore, containing 2.8 per cent. copper, is broken to three-inch

[1] "Wet Methods of Extracting Copper as adopted at Rio Tinto, Spain." By Charles H. Jones, Am. Inst. Min. Eng. February, 1904. *Vide* Eng. and Min. Journal.

size and piled on clay floors in heaps 15 to 30 feet deep, containing several millions tons of ore, "fines" and "coarse" being in alternate layers. The heaps are ventilated by rough stone flues and chimneys, and the surface is cut up by a system of gutters in which the leaching waters, which first start the oxidation and later dissolve the salts, are run. The temperature is regulated to about 100 degrees Fah., below which oxidation is slow, and above which, owing to the generation of steam, free ingress of air is prevented.

Ex.: At San Domingos, in Portugal, two and a-half to three per cent. ores were formerly broken to lumps the size of the fist and piled in heaps 15 to 40 feet thick. They were treated as above.

(ii.) *Slow Heap Roasting.*

Artificial cementation is most suitable for pyritous ores poor in copper, but the fumes produced are a great nuisance. Owing to the impossibility of oxidising all the sulphide and to the formation of some copper oxide during the roast, it is necessary, after a preliminary leaching, to expose the ore to the weather for many years, to complete the formation of sulphate.

Ex.: At Rio Tinto, the process has been used for one and a-half to two per cent. ores. which were roasted over brushwood, firewood, or coals, in heaps of from 200 to 1,500 tons, the amount of firewood required being one quarter cubic foot per ton of ore. The smaller heaps burn for two months and the larger for six months, but the former give the better result. After leaching (as described below under "Solution of the Copper Salts"), the residues, containing about one half per cent. copper, are built, while moist, into heaps ("torreras") which contain several million tons. The sulphides in the heaps decompose with increase of temperature, and given sufficient time the oxidation of the copper will be complete. Leaching of the "torreras" is begun after four to six months.

(iii.) *Heap Roasting with Ferrous Sulphate.*

This is suited for pyritic ores poor in copper, and especially for fines. The ferrous sulphate is obtained as a by-product when the copper is precipitated from the sulphate solution by means of iron. The action of the sulphate is shown in the equation below:—

$$CuFeS_2 + FeSO_4 = CuSO_4 + 2FeS.$$

Ex: At Agordo, in the Venetian Alps, Italy, one to two per cent. fines are crushed, and made into a paste with the mother liquors, containing ferrous sulphate, from the precipitation of copper; the paste is cast in moulds, air-dried for three weeks and built into heaps, which are covered with "smalls" and calcined for from four to five months.

Ex.: At Majdanpec, in Servia, two per cent. mixed sulphide, carbonate, and oxides ores, containing one per cent. sulphuric acid and eight per cent. magnesium and aluminium sulphates (which act in the same way as ferrous sulphate), after drying for a month, are made into heaps of 300 tons each and calcined for three months, with a consumption of seven tons of firewood per heap.

(iv.) *Leaching.*

(*See* under "Solution of the Copper Salts.")

3. Conversion into Sulphite.

(i.) *Roasting and Sulphurous Acid.*

Sulphite is prepared with sulphur dioxide, which affects only the oxide or carbonate, and sulphides have therefore to first receive a thorough oxidising roast.

Neill's Process[1] is primarily for oxides and carbonates in a siliceous gangue, preferably one free from lime and magnesia, but with a preparatory roasting it is just as applicable to sulphides. The process when described had not yet passed out of the experimental stage. It is intended for remote localities where fuel and fluxes are not obtainable.

4. Conversion into Chlorides.

Cupric and cuprous chlorides are produced either by a wet or a dry method.

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[1] "Leaching of Copper Ores by Sulphurous Acid." By E. P ennings. Eng. and Min. Jour., March, 1901.

(a) *Wet Methods.*

For ores requiring no preliminary preparation, the methods will be found under "Solution of the Copper Salts," but for ores containing sulphides the following method may be used:—

(i.) Chlcrination by leaching with ferrous chloride and hydrochloric acid (acidified mother liquors).

Ex.: At Stadtberge the heaps of sulphides, &c., with two to two and a-half per cent. copper, are leached with mother liquors (containing ferrous chloride) acidified with hydrochloric acid. Part of the copper is dissolved, and the remainder is either chloridised or sulphatised by exposing to the atmosphere for a period of three months. The silver in the ore is converted into chloride by the addition of common salt.

(b) *Dry Methods.*

(i.) Henderson's or, more properly, Longmaid's Process. The commercial introduction of this process, which is comparatively rapid and thorough, was the cause of the reopening of several important mines in Spain and Portugal; and, besides, it is used in several countries in Europe for ores containing from three to eight per cent. of copper—especially for the residues from the manufacture of sulphuric acid.

Henderson's patent was to volatilise the chlorides and dissolve the copper remaining with acid; but, the amount of chloride volatilised being insignificant, the following modification was made. The ores are first subjected to an oxidising roast at a moderate temperature, in heaps or in shaft furnaces, followed by a chloridising roast, with 15 per cent. common salt, in reverberatory or muffle furnaces, to convert the copper into chloride (cupric chiefly, but with a little cuprous). The process depends on the sulphur in the calcined pyrite, causing the formation of copper sulphate, which, by double decomposition with the common salt, forms cupric and cuprous chlorides, as shown in the following equations:—

$$2FeS_2 + 4CuO + 15O = 4CuSO_4 + Fe_2O_3.$$
$$4CuSO_4 + 8NaCl = 4CuCl_2 + 4Na_2SO_4.$$

There is also unavoidably a little copper oxide and sulphide present.

The aim is to produce the maximum quantity of cupric chloride (which is soluble in water), and a minimum quantity of ferric sulphate (which increases the consumption of iron in precipitation). These desiderata are obtained by the use of ores containing less than eight per cent. copper (a greater quantity is difficult to oxidise and chloridise), by regulating the amount of sulphur to $1\frac{1}{2}$ times that of the copper in the ore (any excess forming ferric sulphate), and the maintenance of a uniformly low red heat (a greater heat causing volatilisation of cupric chloride). The gases (sulphur dioxide, hydrochloric acid, and chlorine) produced by the roast are absorbed by falling water in masonry towers.

Ex.: The process, with modifications, was formerly used at Rio Tinto, where $2\frac{3}{4}$ per cent. ores were roasted in heaps with 40 lb. common salt to the ton, and leached with water to extract the copper (about one-fifth) rendered soluble.

$$FeS_2 + H_2O + 7O = FeSO_4 + H_2SO_4; \quad CuO + H_2SO_4 = CuSO_4 + H_2O.$$

The residue was then removed and further roasted for four to six months while subjected to the oxidising action of sulphuric acid formed by the oxidation of sulphur dioxide from a covering of raw ore.

$$SO_2 + H_2O + O = H_2SO_4.$$

The ore was mixed with two or three per cent. of common salt and manganese dioxide for the purpose of producing copper chlorides:

$$4NaCl + 2H_2SO_4 + MnO_2 = MnCl_2 + 2H_2O + Cl_2 + 2Na_2SO_4.$$
$$CuSO_4 + Cl_2 = CuCl_2 + SO_2 + O_2.$$
$$Fe_2O_3 + 3Cl_2 = Fe_2Cl_6 + O_3.$$
$$3CuSO_4 + Fe_2Cl_6 = 3CuCl_2 + Fe_2(SO_4)_3.$$

Ex: The richer coarse ore at Rio Tinto was (in 1892) roasted in piles with two per cent. common salt, rendering a quarter of the copper present soluble. The residue after leaching was subjected to a further roasting.

Ex.: At Oker, in Germany, an ore having the following composition was treated:—pyrite=60 per cent.; chalcocite=23 per cent.; blende=6 per cent.; galena=2 per cent.; gangue = 9 per cent. After calcination in pyrite burners connected with sulphuric acid works, the ore was mixed with 15 per cent. of mixed alkaline chlorides and ground to 0.08-inch mesh. The mixture was charged 2¼ tons at a time into a gas furnace, and heated to low redness for four hours; rabbled for five hours without firing and with open ports; and then drawn. In this manner five tons were worked off per twenty-four hours with a consumption of 10 per cent. coal; 75 per cent. of the copper contents were rendered soluble in water (cupric chloride and neutral sulphate), 20 per cent. soluble in dilute acids (cuprous chloride, cupric oxychloride, oxide and basic sulphate), while 5 per cent. was soluble only in aqua regia (cuprous sulphide).

Ex.: At Antwerp, four per cent. ores from Norway, containing five per cent. sulphur after treatment in sulphuric acid works, are crushed and mixed with 20 to 25 per cent. common salt. They are then roasted for six hours with a temperature of 500 degrees to 600 degrees C. in a muffle furnace, holding 3¾ and 4½ ton charges, and reducing the sulphur to 0.20 per cent. The copper is then in the form of cuprous chloride and oxide.

$$2CuS + 2CuO + 4NaCl + 7O = 2CuCl + Cu_2O + 2Na_2SO_4 + Cl_2.$$

Ex.: At Natrona,[1] Pennsylvania, Spanish pyrites cinders, containing two per cent. copper are treated. The cinders are ground with 10 per cent. common salt, and roasted in 4½-ton lots in muffle furnaces at a dull red heat (800 degrees Fahr.) for eight hours. The copper is then chiefly chloridised.

Ex.: In Great Britain, Henderson's Process is combined with the Claudet Process (for precipitating silver as iodide). The ore, after roasting in muffle furnaces at a dull red heat with from 13 to 20 per cent. common salt, contains 77 per cent. chlorides and 20 per cent. oxide. The gases given off are condensed and used for leaching.

Ex.: At Falun, Sweden, 3½ per cent hard ores are roasted in heaps driving off 10 per cent. sulphur; mixed with 14 per cent. common salt and ground in ball mills; subjected to a chloridising roast in Howell and White calciners with continuous charging, 15 tons in twenty-four hours. When completely chlorinated, the ore is transferred to wooden vats. and cupric chloride is dissolved by a first wash of weak acid, a second of weak liquors from a previous charge, and a third of clean water.

(ii.) Hoepfner in 1902 took out a patent in the United States by which—

1. Sulphides are roasted and sulphur dioxide is condensed.
2. Copper sulphate is converted into cupric chloride by common salt.

III.—Solution of the Copper Salts.

The methods of dissolving the salts will be given in the order in which the salts have been prepared.

A. AND B.—OXIDE, CARBONATE, AND ARSENATE.

These, either native or artificial, may be dissolved by the following solvents, of which, owing to their energetic action, the acids are to be preferred, whenever their cost will allow, except in cases where the ore contains substances (such as carbonates) soluble in acids:—

(a) By Sulphuric Acid (H_2SO_4).

The acid is prepared in sulphuric acid chambers from pyrite and nitre, and leaching of the ore takes place in lead-lined or stone chambers.

The only objection to the employment of sulphuric acid is that basic salts are formed, as well as ferric sulphate and free sulphuric acid, which cause loss of iron during precipitation of the copper.

Ex.: Stadtberge.

[1] "Extraction of Copper from Burnt Pyrite." By Joel P. Clemmer, in Min. Ind., Vol. VIII.

The latter difficulty—the loss of iron—is overcome in Van Arsdale's Process,[1] in which sulphur dioxide, derived from the roasting of sulphides, is used as a precipitant. This process, patented in 1903, purposes to extract the copper from low-grade ores by means of already heated sulphuric acid solution, containing incidentally copper sulphate. The solvent is regenerated in the precipitation of part of the copper, and used for fresh ore after expulsion by heat of any sulphur dioxide contained. As a matter of fact, the SO_2 is expelled simply by releasing the pressure in the pressure tank, which is already heated. Iron and other substances are dissolved as well as copper, and the solution has, therefore, from time to time to be neutralised, when, on heating and injecting air, the iron is precipitated, and carries down arsenic and other impurities. Iron, if not present in greater quantity than the copper, does not interfere with the reactions.

(*b*) By Hydrochloric Acid (HCl).

This acid is preferred to sulphuric acid because of the smaller proportion of basic salts formed, although its consumption is greater owing to the iron oxides in the ore being attacked during the leaching operation.

Ex.: At Stadtberge, Westphalia, hydrochloric acid, owing to its cheapness, was used after the abandonment of the sulphuric acid process. The leaching tanks were of wood, and held from 29 to 90 tons of ore. The solutions, gradually increasing in acidity, were allowed to remain twelve hours in each tank, and saturation was obtained in from ten to twelve days. The acid required amounted to from five to seven times the weight of the copper.

Ex.: In Waldeck, Germany, attempts were made to extract the copper (three-quarters to one per cent.) in the Bunter Sandstone, but failed because of the presence of half to one per cent. lime, which had to be first dissolved. The ore was crushed and charged into sixteen tubs 13 feet in diameter and 4 feet deep, furnished with agitators; 20 tons of ore were treated per day, the ore being delivered at the works at 4s. per ton. The impure acid used cost 2s. per 100 lb., and each ton of ore required 400 lb. of acid, which before use was diluted with water.

A slight modification of the acid process has been patented (December, 1901) by Waterbury in the United States. Ore is to be leached with acid in a tank, hot air being forced in at same time from a perforated pipe near the bottom of the tank.

(*c*) By Ferrous Chloride ($FeCl_2$).

This salt may be used for dissolving cupric oxide and carbonate or roasted sulphides, forming cupric chloride (soluble in water) and cuprous chloride (soluble in excess of ferrous chloride).

$$3CuO + 2FeCl_2 = CuCl_2 + 2CuCl + Fe_2O_3.$$
$$3Cu_2O + 2FeCl_2 = 4CuCl + Fe_2O_3 + 2Cu.$$
$$2CuO + Cu_2O + 2FeCl_2 = 4CuCl + Fe_2O_3.$$

The cupric chloride itself decomposes copper sulphide as well as silver sulphide.

$$Cu_2S + 2CuCl_2 = 4CuCl + S.$$

(i.) *Direct Action of Ferrous Chloride on the Oxidised Ore or Roasted Sulphide.*

(Old Hunt and Douglas Process.)

The ore is agitated in wooden vessels with ferrous chloride solution (prepared by mixing ferrous sulphate and common salt, and crystallising out the sodium sulphate). The ore and solution are kept at a temperature of about 70° C. till—after three or four days—the copper has dissolved, when the

[1] Engineering and Mining Journal, 6th June, 1903.

solution is filtered from the precipitated ferric oxide. The process was formerly much used in the United States, its advantages being the small consumption of iron, the absence of a chloridising roast, and the small amount of fuel needed: but the trouble in separating the ferric oxide has caused its almost complete abandonment. Another disadvantage is that, owing to the presence of cuprous chloride, which forms an insoluble iodide, the Claudet Process for separating the silver is not available.

Ex.: At Ore Knob, North Carolina, U.S.A., calcined ores containing 7·75 per cent. oxide and 4 per cent. sulphate were leached with ferrous chloride solution in wooden vats six feet in diameter, holding 1½ tons of ore. After stirring for eight hours, the ore was allowed to settle, and the solutions drawn off for precipitation.

(ii.) *Indirect Action of Ferrous Chloride on Roasted Ore, followed by a Sulphuric Acid Leaching.*

(New Hunt and Douglas Process.)

This modification was devised because of the trouble in separating the ferric oxide and the difficulty in saving the silver by the old process. Its great advantage is the rapidity with which solution takes place.

Ex.: At Kansas City, Missouri, U.S.A., this process is used for calcined argentiferous lead-copper mattes containing up to 300 oz. silver per ton and 30 per cent. copper. After an oxidising roast at a low temperature, the copper oxide and sulphate formed are dissolved with dilute sulphuric acid. The addition of common salt to the solution results in the formation of ferrous chlorides, which converts the copper sulphate into cupric chloride (in greater part). The common salt must not be in excess, as silver chloride would be dissolved. Calcium chloride (obtained by the precipitation of copper with milk of lime) may be used to chloridise the copper, but in this case a precipitate of calcium sulphate has to be filtered off. The silver, precipitated by cuprous chloride, and lead remain undissolved, and may be obtained separately.

(*d*) By Sulphurous Acid (SO_2).

(Neill's Process.)

The sulphur dioxide, produced either from the roasting of pyrite or of the copper ore itself if it be a sulphide, attacks copper oxide or carbonate, forming sulphite ($Cu_2SO_3.H_2O$), which remains in solution in excess of sulphurous acid.

$$2CuO + H_2SO_3 = Cu_2SO_3 + H_2O + O.$$

Lime and magnesia, being soluble in sulphurous acid, are objectionable because they increase the consumption of sulphur dioxide, but otherwise they are inert. Very little of the other metals in the ore are dissolved, and the copper is therefore obtained in an unusually pure condition.

In practice it is proposed, after crushing the oxides, carbonates, or roasted ore to a 20-mesh screen, to charge into covered wooden tanks, containing water (two tons per ton of ore) with a little absorbed sulphur dioxide, the washings from the previous charge and from the gas absorption tower connected with the leaching tank. The sulphur dioxide is forced under pressure by air compressors into the false bottom of the leaching tank in which ore and liquid are kept in continual agitation by the gases. The solution could be completed in from one to four hours in a single tank, but it is better to have a series, one over the other, so that the gas from the lowest can be passed into the others. From the leaching vats the pulp and solution are delivered into a storage vat from which the solution and slimes are forced by compressed air into a filter press, to separate the solution from the pulp. The sands in the tank and slimes in the filter press are washed with a small quantity of water acidified with sulphuric acid which is either passed on to the steaming tank or back to the leaching tank.

This process seems to be most admirably suited to our inland copper districts, owing to the low cost and small amount of solvent used, to the simplicity of the plant (even simpler than that successfully used in the sulphuric acid process), and to the ease of reduction of the copper salt obtained. It is true that its adoption would be in the nature of an experiment, and many

difficulties would necessarily have to be overcome, but the small amount of fuel needed, the cheapness of the treatment, the availability of the solvent, and the pure product obtained all give it a strong claim for a trial.

Ex.: Experiments on silicified Triassic sandstone containing blue and green carbonates with some oxide have proved that 95 per cent. of the copper can be dissolved in four hours.

(*e*) By Ferric Chloride (Fe_2Cl_6).

The ferrous chloride in the liquor obtained in the precipitation of hydrochloric acid solutions is oxidised on exposure to the atmosphere to ferric chloride, which is capable of dissolving metallic copper, cuprous and cupric oxides, and copper carbonates.

(*f*) By Other Solvents.

Ammoniacal compounds and sodium hyposulphite have been suggested, but they are either too slow in action or else too expensive for practical use.

C.—CHLORIDES.

Cupric chloride is soluble in water, but cuprous chloride requires the addition of ferric chloride or ferrous chloride and hydrochloric acid.

(*a*) By Water.

Leaching with water is used in the Henderson Process to extract the cupric chloride.

Ex.: At Rio Tinto, about one-fifth of the copper contents was extracted after the chloridising roast.

Ex.: At Oker, three-quarters of the copper contents was rendered soluble in water.

Ex.: At Natrona, the chloride produced was leached out with water and the ferric oxide residue sent to iron works.

Ex.: In England, tanks of wood tightly caulked, and 10 ft. × 11 ft. × 4 ft. deep, are used with removable false bottom of perforated tiles or firebrick covered with a three-inch layer of cinders; fifteen-ton charges; nine to ten successive washings of water, condensation tower liquors, or very weak cupriferous solutions from the previous leachings, the last two washings being acidified. The leachings require forty-eight hours and the copper contents are reduced to 0.18 per cent.

(*b*) By Ferric Chloride.

In the Henderson and Dotsch Processes ferric chloride leaching is employed in extracting the cuprous chloride. Direct leaching is not advised unless the cost of fuel prohibits a chloridising roast.

(i.) Direct leaching with ferric chloride.

Ex.: At Rio Tinto, the method employed to replace the Dotsch Process for fines is to simply leach them in tanks with ferric chloride solutions obtained during the precipitation of copper dissolved from the roast heaps. The following are the reactions involved:—

$$CuS + Fe_2Cl_6 = CuCl_2 + 2FeCl_2 + S \text{; and } Cu_2S + Fe_2Cl_6 = 2CuCl + 2FeCl_2 + S.$$

(ii.) Indirect leaching with ferric sulphate and common salt (Dotsch Process).

Ex.: At Rio Tinto, a process was formerly in use for cupriferous pyrite fines, containing $2\frac{1}{2}$ per cent. copper. The ore was crushed fine by rock breakers, mixed with $\frac{1}{2}$ per cent. common salt and stacked in heaps, 50 feet square and 18 feet high, traversed by dry stone flues. The heaps were then drenched with a mixed solution of ferric sulphate and common salt.

$$Fe_2(SO_4)_3 + 6NaCl + 3O = Fe_2O_3 + 3Na_2SO_4 + 6Cl.$$
$$2FeSO_4 + 4NaCl + 3O = Fe_2O_3 + 2Na_2SO_4 + 4Cl.$$

The chlorine freed attacks both copper and iron sulphides, forming cupric and ferric chlorides. The chlorides were dissolved in a subsequent leaching with ferric chloride, which had to be regenerated by the action of chlorine on the ferrous chloride

formed in precipitating the copper. Half the copper in the ore was dissolved within four months, and 86 per cent. of the remainder in the following two years. The pyrite in the ore was unacted on, but in addition to the slowness of the process the costs were excessive owing to the large amount of chlorine lost.

Ex.: At Antwerp, solution tanks are 82 ft. × 11 ft. 6 in. × 11 ft. 6 in. deep, with filter bottom consisting of leached ore and straw. First wash is of heated precipitation liquors which are allowed to remain in contact ten hours; the second is of heated condensing tower liquors further acidified if necessary; the last washing is with hot water. Residues contained only 0.25 per cent. copper.

(iii.) Leaching with ferrous chloride and free hydrochloric acid is practised in the Henderson Process, and is really only a slight modification of the above. It is based on the fact that the result of the oxidation of ferrous chloride in the presence of hydrochloric acid is ferric chloride.

Ex.: At Stadtberge, crushed chloridised ores are leached by means of the mother liquor (containing ferrous chloride), obtained after the precipitation of copper, to which hydrochloric acid has been added. The solution is carried out in false-bottomed tanks of wood with caulked joints, holding five to ten tons of ore, and is complete in three days after twelve or sixteen washes. The false bottom is made of perforated planks upon which is a filtor layer of coke, ashes, or straw.

Ex:. At Oker, lixiviation of the chlorides is done in false-bottomed lead lined tanks of five to ten tons capacity by three washes of precipiation liquors (containing ferrous chloride and hydrochloric acid or acid liquors from the condensing towers) and six of water, each wash remaining in contact with the ore for only a few hours. The first washes dissolve 75 per cent. of copper contents. The cuprous chlorides and oxides are dissolved by the acid liquors from condensing towers connected with roasting furnaces or by dilute acid, the solution being allowed to remain in contact with the ore for two days.

Ex.: In Great Britain the leaching tanks, ten feet square and five and a-half feet deep, hold twenty tons of ore, which is washed with acid solutions (obtained by condensation of the gases from roasting the ore), followed by hot water.

Ex.: At Antwerp, the mixture of copper chloride and oxide is first lixiviated with old precipitation liquors and then with solutions of the gases given off during the roasting of the ore. The residue contains 0.25 per cent. copper.

D.—SULPHATE.

The sulphate being easily soluble in water, only one method of solution is necessary.

(*a*) By Water.

Copper sulphate often occurs in mine waters, having been produced by oxidation of the ore exposed in the workings and dissolved by circulating waters.

Ores containing disseminated copper sulphate may be leached in wooden vats, in masonry tanks, or on stamped clay or loam floors. The solutions are circulated, so that the strongest are put on to fresh ore, the weakest into exhausted ore.

Ex.: At San Domingos (and Rio Tinto) when the method of exposing to natural oxidation was employed, the heaps were periodically watered from a pipe reticulation and leached with acid mother liquor containing ferric sulphate (obtained from the precipitation of the copper), which, besides dissolving the copper, accelerated the oxidation of the sulphides. The copper in the residues after six years' treatment amounted to ¼ per cent., which it did not pay to extract; the very large quantity of water required necessitated tho construction of immense reservoirs, of one and a-half to five million tons capacity.

Ex.: At Rio Tinto later, the ores after the first roasting were transferred to cement-lined masonry tanks, 100 feet by 34 feet by 5 feet, with false bottoms of perforated planks. The first leaching lasts two to six hours, then there are five or six additional leachings, the ore being left under water eight to ten hours each time. The leached ore then contains ½ per cent. copper, and after decomposition in "terreras" as described is leached during a period of five years, at the end of which time 88 per cent. of the copper has been extracted.

Ex.: At Stadtberge, the copper sulphate formed by the action of nitrous and sulphurous gases is simply leached with water (or the acid liquor from former precipitations).

Ex.: At Agordo, leaching is done in square wooden vats with false bottoms of boards or acid-proof stoneware and filters of straw, coke, &c. The vats have a capacity of up to 200 tons.

E.—SULPHIDE.

The solution of the sulphide, being most difficult of all, is seldom attempted directly, though the action given below does occur.

(*a*) By Ferric Sulphate [$Fe_2(SO_4)_3$].

The "brown liquor" from the precipitation of cement copper by iron from sulphate solutions, after oxidation, consists in part of ferric sulphate. The liquor is reduced, in passing over cupriferous pyrite, to ferrous sulphate and copper is dissolved in proportion to the quantity of iron reduced.

$$Fe_2(SO_4)_3 + Cu_2S + H_2SO_4 = 2CuSO_4 + 2FeSO_4 + H_2S.$$

Or
$$Fe_2(SO_4)_3 + Cu_2S = CuSO_4 + 2FeSO_4 + CuS;$$

and
$$Fe_2(SO_4)_3 + CuS + 3O + H_2O = CuSO_4 + 2FeSO_4 + H_2SO_4.$$

This action is important in all the sulphatising leaching processes. It is very desirable that no excess of ferric sulphate remain in the solution, as the consumption of iron would be increased by it during the precipitation of the copper thus:—

$$Fe + Fe_2(SO_4)_3 = 3FeSO_4$$

It has been noticed that as the copper content decreases the amount of copper dissolved decreases in greater ratio, though the amount of free acid increases. This is owing to the action of pyrite on the ferric sulphate, and, as it is more energetic with increase of temperature, the large consumption of iron needed to precipitate the copper in solutions from the highly heated roast heaps at Rio Tinto is thereby explained.

Ex.: At Rio Tinto the above action is made use of to dissolve the unaltered sulphides in the roasted (sulphatised) ore.

F.—SULPHITE.

The sulphite is produced in only one process, and its solution then is easy.

(*a*) By Sulphurous Acid.
(Neill's Process.)

The sulphur dioxide besides forming sulphite in this process is necessary to keep that salt in solution. (*See* under "Preparation" and "Precipitation.")

IV.—Precipitation of the Copper or Copper Salt from Solution.

1.—BY METALLIC IRON.

The reduction of the copper, which, as shown above, is in solution in the form of sulphate or chloride (cupric or cuprous), is generally brought about by means of metallic iron.

$$CuSO_4 + Fe = Cu + FeSO_4;$$
$$CuCl_2 + Fe = Cu + FeCl_2;$$
$$2CuCl + Fe = 2Cu + FeCl_2.$$

(*a*) Reduction from Solution.

Theoretically: 88.8 parts of iron precipitate 100 parts of copper from cupric solutions, and 44.4 parts of iron precipitate 100 parts of copper from

cuprous solution, but in practice, with sulphate solutions, 200 to 300 parts of iron may be required to precipitate 100 parts of copper. This is owing to the presence of ferric salts and free acid, the latter from the oxidation of pyrite as already shown, and the former from the oxidation of ferrous salts.

$$2FeSO_4 + H_2SO_4 + O = Fe_2(SO_4)_3 + H_2O.$$
$$3FeCl_2 + H_2O = Fe_2Cl_6 + FeO + H_2.$$

Both the acid and the ferric salts attack metallic iron, and it is therefore necessary that the solution should be as free as possible from them.

$$H_2SO_4 + Fe = FeSO_4 + H_2;$$
$$Fe_2(SO_4)_3 + Fe = 3FeSO_4.$$

The latter may be reduced by filtering the liquid through copper sulphide ores, as shown under "Solution of the Sulphide (E.)" and in the following equation:—

$$7Fe_2(SO_4)_3 + FeS_2 + 8H_2O = 15FeSO_4 + 8H_2SO_4.$$

Basic salts render the cement copper impure, and it is therefore advisable to allow the solutions to work on the ores till neutral.

The iron is used in the form of wrought iron, pig iron, sponge and bar iron. Powdered iron, turnings, and clippings act most rapidly. Bar iron and grey pig give a coarse pulverulent cement, while white iron throws down coherent copper.

The deposition of the copper is accelerated by heating the solution (by steam or hot air, the latter in Waterbury's Patent), by agitating it (by mechanical stirrers, by a current of air, or by circulation from vat to vat), and by increasing the surface of the iron exposed to the liquid.

The "cement" (the copper precipitate), owing to its commuted and bulky state, is extremely liable to oxidation, so that it seldom contains over 80 per cent. copper when delivered to the smelters.

Any silver in solution, unless previously precipitated by sulphuretted hydrogen, potassium iodide, or alkaline sulphides, goes down on the first of the copper reduced. It may be precipitated as iodide by the addition of sufficient zinc iodide, which is regenerated by the action of metallic zinc on the silver iodide (as in the Claudet Process).

Antimony and arsenic are also deposited with the copper, and, together with the graphite of the pig, particles of iron, and silica, tend to render the "cement" impure. These impurities occur chiefly in the finer portion of the precipitate, which is thrown down as the solution becomes poorer in copper.

The use of pig and scrap iron is not to be thought of for our inland deposits because of the heavy freights. The difficulty might, however, be obviated by the use of ground sponge iron produced locally. This material has given fairly good results in England, though, owing to the large quantity of impurities, it could not compete with scrap iron. It is produced by heating, at a full red heat, a mixture of coke dust (or possibly charcoal), 6 cwt., and purple ore (the residue from the copper leaching vats), one ton, in a special reverberatory furnace, for from nine to twenty-four hours, according to the position of the ore on the hearth. An intense heat is not required for the reduction, and fusion does not take place. After heating the material is drawn from the furnace into cast iron vessels, which are hermetically sealed till cold. The sponge is then ground under edge runners.

Ex.: Mine waters containing copper sulphate are known as "cement" waters. They are run through a system of troughs inclined at angles of about 10 degrees, arranged in steps, and filled with iron or crossed by iron gratings.

Ex.: At Wicklow, Ireland, the water is conducted through troughs, inclined 7 degrees to 10 de rees, opening at intervals into tanks. Iron in the troughs precipitates the copper, which is washed into the tanks, and there collected.

Ex.: Cornwall Mines.

Ex.: Mount Mor, an.

Ex.: At San Domingos copper was precipitated by pig iron stacked in asphalted basins 13 feet square, of which there were 240. The iron consumed was double the weight of the copper precipitated owing to ferric sulphate in the liquors. The cement, containing 65 per cent. copper, after drying was exported.

Ex.: In the Old Hunt and Douglas Process only sixty to seventy parts of iron are required for 100 parts of copper, because of the copper being in the cuprous form, and the cement is unusually pure. Precipitation is rapid, and, the solutions being reused, it is not necessarily complete for each cycle. Solutions are, therefore, not exposed long, and only small quantities of basic salts are formed.

$$2CuCl_2+2CuCl+2Fe=4Cu+Fe_2Cl_6.$$

Ex.: At Rio Tinto, the sulphate solutions pass from settling tanks into a series of cemented or asphalted masonry tanks 50 feet long, 6 feet wide, and 3 feet deep; and from the tanks the solution runs through inclined masonry troughs 3 feet 3 inches to 6 feet 6 inches wide and 1 foot 4 inches to 1 foot 8 inches deep for several miles, with an inclination of 0.3 per cent. at first to two per cent. towards the end. Both tanks and troughs are loosely filled with iron. The consumption of iron has been very high ($2\frac{1}{2}$ tons for each ton of copper precipitated), owing to the formation of ferric salts, and the cement is rendered very impure (containing only 60 to 85 per cent. copper), owing to the precipitation of basic iron salts.

In the natural oxidation process, the solutions have required two tons of iron per ton of copper, and the cement contained only 65 per cent. copper. By careful previous reduction of the ferric salts, and by regulating the velocity of the solutions in the precipitating tanks, it has been found possible to reduce the consumption of iron to 1.4 tons per ton of copper precipitated.

In the ferrous sulphate roast modification, the consumption of iron is equal to the weight of the copper precipitate.

Ex.: At Stadtberge, 127 parts of iron are required to precipitate 100 parts of copper. At these works the silver is precipitated with a little copper in the first tank, the remaining copper, free from silver, being thrown down in other tanks. Green vitriol ($FeSO_4$) is also produced from part of the resulting solutions

Ex.: At Oker, the solutions are heated in lead-lined wooden tanks, and the copper is precipitated in from one to three days by means of wrought-iron (in the proportion of one part to each part of pure copper).

Ex.: At the Bede Metal Works, England, ground iron sponge is employed as a precipitant, but, as it contains unreduced iron oxide, ashes, and coal, its use has not been extended.

Ex.: At Natrona, Pennsylvania, the precipitation of the copper on thin iron, in false-bottomed tanks, is hastened by the injection of steam, which, besides heating the solution, mechanically keeps the iron free of copper. The cement produced here contains 90 per cent. copper.

Ex: At the Antwerp Works, cupric chloride is reduced in twenty-four hours by scrap iron (equal in weight to the copper produced), in seven nine-ton vats, in which the solution is heated. The cement contains 80 to 88 per cent. copper. The residues are sold to iron works.

Ex.: In Great Britain, precipitation in the Henderson-Claudet Process is by scrap iron (110 parts to each 100 of copper), in a solution kept at 150 degrees by the injection of steam. The cement produced contains 75 per cent. copper.

(b) Reduction of Solid.

(New Hunt and Douglas Process.)

The solid cuprous chloride may be reduced under water by metallic iron—one-half the weight of the copper precipitated. Silver in the ore having been converted into chloride may be extracted from the residue.

Ex.: At Kansas City.

2.—BY VOLATILISATION OF THE SOLVENT.

(Neill's Process.)

Copper sulphite in solution in sulphurous acid is readily precipitated as a red crystalline solid ($CuSO_3.Cu_2SO_3.2H_2O$), containing 49.1 per cent. copper, by simply driving off excess of sulphur dioxide. This is done in a wooden tank by heating to boiling by waste steam in a pipe coil. The slight amount of copper then remaining in solution is readily precipitated by lime (or iron), in separate tanks, preferably, while the solution is still hot. The plant may be so arranged that nearly all the sulphur dioxide except that combined with the copper can be saved and reused.

This process deserves very serious consideration by Queensland mine-owners, as the great expense of freight on the iron needed for most of the other processes is here entirely obviated.

3.—BY SULPHUROUS ACID.

(*a*) To Metal.

(Van Arsdale's Process.)

This process, which has not yet, as far as known, been put into actual practice, depends on the fact that sulphur dioxide under certain circumstances precipitates part of the copper from cupric sulphate solution, and at the same time generates sulphuric acid.

$$3\ CuSO_4 + 3\ SO_2 + 4\ H_2O = Cu_2SO_3.CuSO_3 + 4\ H_2SO_4$$
$$= Cu + 2\ CuSO_4 + 2\ H_2SO_4 + 2\ SO_2 + 2\ H_2O.$$

These reactions take place in a boiling solution under ordinary atmospheric pressure, but when under increased pressure the yield of copper is raised to from 40 to 50 per cent. of the contents.

The solution, after separation from the ore, which needs careful washing, is allowed to drain through a tower packed with coke, &c., and exposed to the action of sulphur dioxide from burning pyrite. It is then heated by steam to 100° C. in a lead-lined steel tank, similar to a chlorination barrel, to cause a pressure of 30 lb. per square inch and the precipitation of 50 per cent. of the copper contents.

(*b*) To Chloride.

(New Hunt and Douglas Process.)

Cuprous chloride is precipitated from solution by the reducing action of sulphurous acid gas, sulphuric acid being regenerated at the same time:

$$CuCl_2 + CuSO_4 + SO_2 + 2H_2O = 2CuCl + 2H_2SO_4.$$

The precipitate is readily separated from the liquid, and is then reduced by metallic iron.

Into the solution decanted from the cuprous chloride hot air is blown to expel any sulphur dioxide or oxidise it to sulphuric acid for use again in leaching.

The amount of zinc and iron in solution gradually increases, these metals not being precipitated by sulphurous acid, and they may therefore be saved as well as the copper.

Ex.: At Kansas City, sulphur dioxide is passed through cupric chloride solution to precipitate cuprous chloride—

$$2CuCl_2 + SO_2 + 2H_2O = 2CuCl + H_2SO_4 + 2HCl.$$

The same reactions as above occur in Hoepfner's Process.

4.—BY MILK OF LIME (CaH_2O_2).

(New Hunt and Douglas Process.)

Milk of lime precipitates copper hydroxide from cupric chloride and cuprous oxide from cuprous chloride solutions, the solution obtained being available for chlorinating a fresh charge. In the case of copper sulphate, calcium sulphate is precipitated with copper hydroxide, and the use of lime is therefore prohibited. The bulk of the precipitates and the difficulty in smelting them have hitherto been considered deterrents, but it would probably be much cheaper to employ lime than iron at many of our inland copper deposits, there being generally deposits of limestone in the vicinity, from which the lime could be prepared.

Ex.: At Kansas City.

5.—BY SULPHURETTED HYDROGEN (H_2S).

This gas is only to be used when iron is not available. It may be produced by passing sulphur dioxide gas (from the calcination of pyrite), together with water vapour, over red-hot coke or charcoal, or by forcing the same gas by a steam jet through glowing charcoal in a shaft furnace, alternately with air, to keep the fuel burning, as in the production of water gas.

$$SO_2 + 3C + H_2O = H_2S + 3CO.$$

Sulphuretted hydrogen may be prepared by leading producer gas (from raw fuel) over red-hot pyrite.

$$2FeS_2 + 4H_2O + 2CO + O = 4H_2S + F_2O_3 + 2CO_2.$$

The product of precipitation by sulphuretted hydrogen is copper sulphide (CuS) containing 66 per cent. sulphur and equivalent to a high-grade ore.

Ex.: Precipitation by sulphuretted hydrogen was formerly practised in Norway and Spain.

Ex.: At the Bede Metal Works, where sulphuretted hydrogen was employed for a time, the process cost more than precipitation by iron, and was therefore abandoned.

6.—BY ELECTROLYSIS.

It has been proposed to precipitate copper from its solutions by electricity, but the expense prohibits it, one horse-power per hour precipitating only ½ lb. copper at a cost of 1.71d. per lb., while, in the case of refining, 2½ lb. are precipitated at a cost of only 0.27d. per lb.

Owing to the expense of electricity in Queensland, due to the absence of cheap natural power, electrical precipitation may be dismissed from consideration.

V.—Treatment of the Copper Precipitates.

1.—CEMENT COPPER.

The generally impure bulky incoherent metal deposited on metallic iron is washed as free as possible of basic iron salts, metallic iron, graphite, silica, antimony, and arsenic. It is then, if containing more than 55 per cent. copper, refined direct, or else smelted in a reverberatory furnace for blister copper, and then refined; but if very impure, containing less than 15 per cent. copper, it is smelted for matte with the addition of raw ores.

Ex.: At Stadtberge, the washer, treating five tons of "cement" in ten hours, is a wooden drum 10 feet long and 4 feet in diameter, provided with an internal spiral cleat. A stream of water passes through the drum in the opposite direction to the copper, and, as a result, two-thirds of the copper contents are obtained (assaying 90 to 95 per cent.). The slimes, containing 10 to 25 per cent. copper, are agglomerated with lime and smelted.

Ex.: At Antwerp, the cement copper is washed on iron sieves with water, under a pressure of two atmospheres, to dissolve soda sulphate. The cement is then, to prevent oxidation, pressed into cakes in a hydraulic press, under pressure of fifty atmospheres.

The copper obtained in Van Arsdale's Process simply needs to be melted down. It may, however, contain precipitated salts of iron and other impurities, and would then have to be smelted.

2.—COPPER SULPHITE.

(Neill's Process.)

The sulphite, after washing and drying, is reduced to metallic copper by fusion in a reverberatory furnace or in a crucible, practically without fluxes and without the formation of a slag. The copper produced is pure, and free from gold and silver.

3.—CUPRIC OXIDE.

(New Hunt and Douglas Process.)

Reduction to metal is brought about by smelting with charcoal, and refining if necessary.

4.—COPPER SULPHIDE.

(From Precipitation by Sulphuretted Hydrogen.)

The precipitate is washed, compressed in a filter press, and reduced in reverberatory furnace.

VI.—Details.

1.—PLANT.

(*a*) General.

As each separate plant differs so greatly from every other, the dearth of detailed information regarding those in operation is to some extent explicable. The example given below is of one of the most important works in the United States.

Ex.: At Natrona, where 200 tons of ore are treated per day, fourteen muffle furnaces (capacity 12 tons in three charges per twenty-four hours) are in operation, and one is held in reserve, all being connected with condensing towers.

The following diagrammatic plans of the arrangement of the plant at these works are from Vol. VIII. of the "Mineral Industry":—

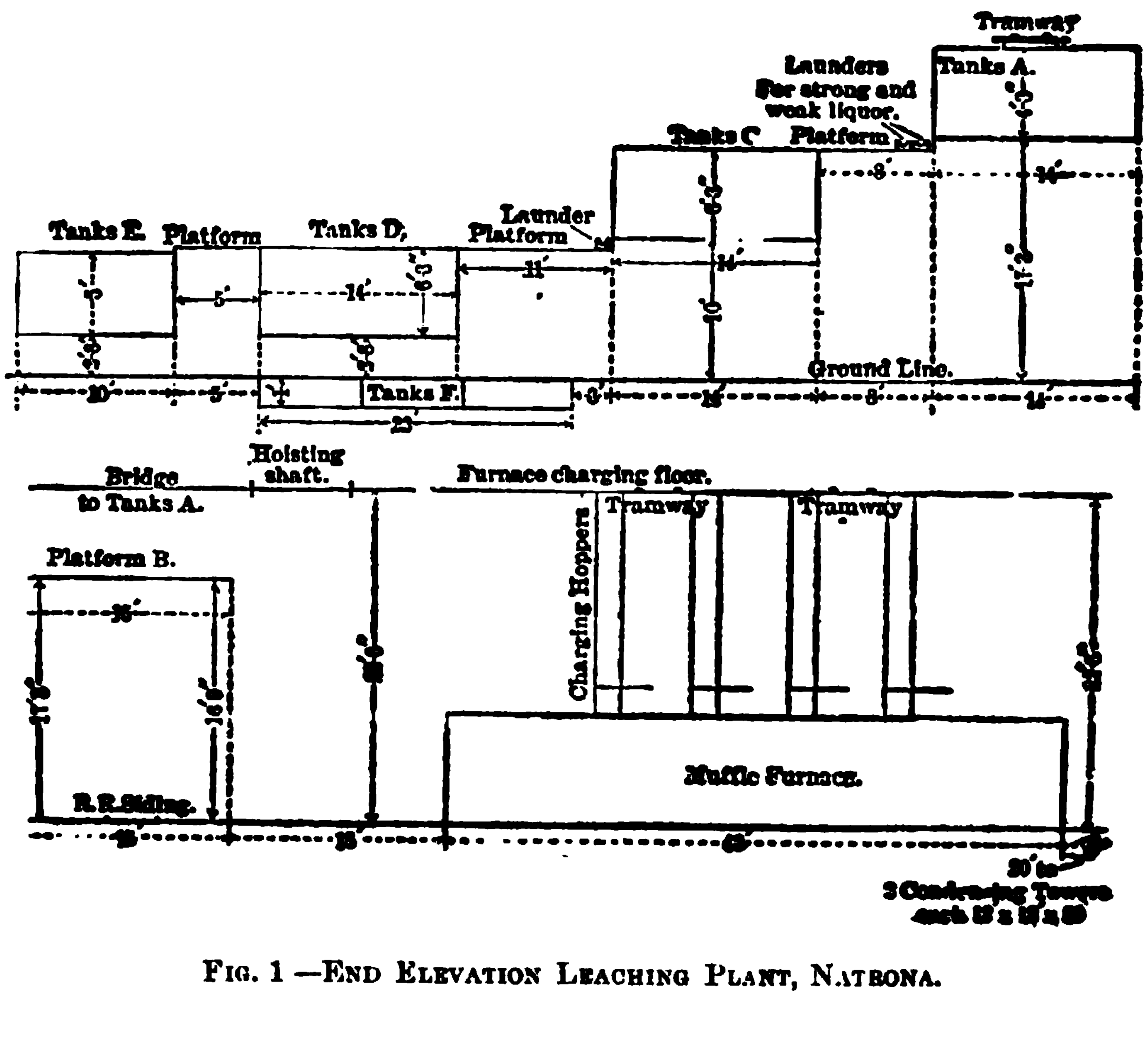


Fig. 1.—End Elevation Leaching Plant, Natrona.

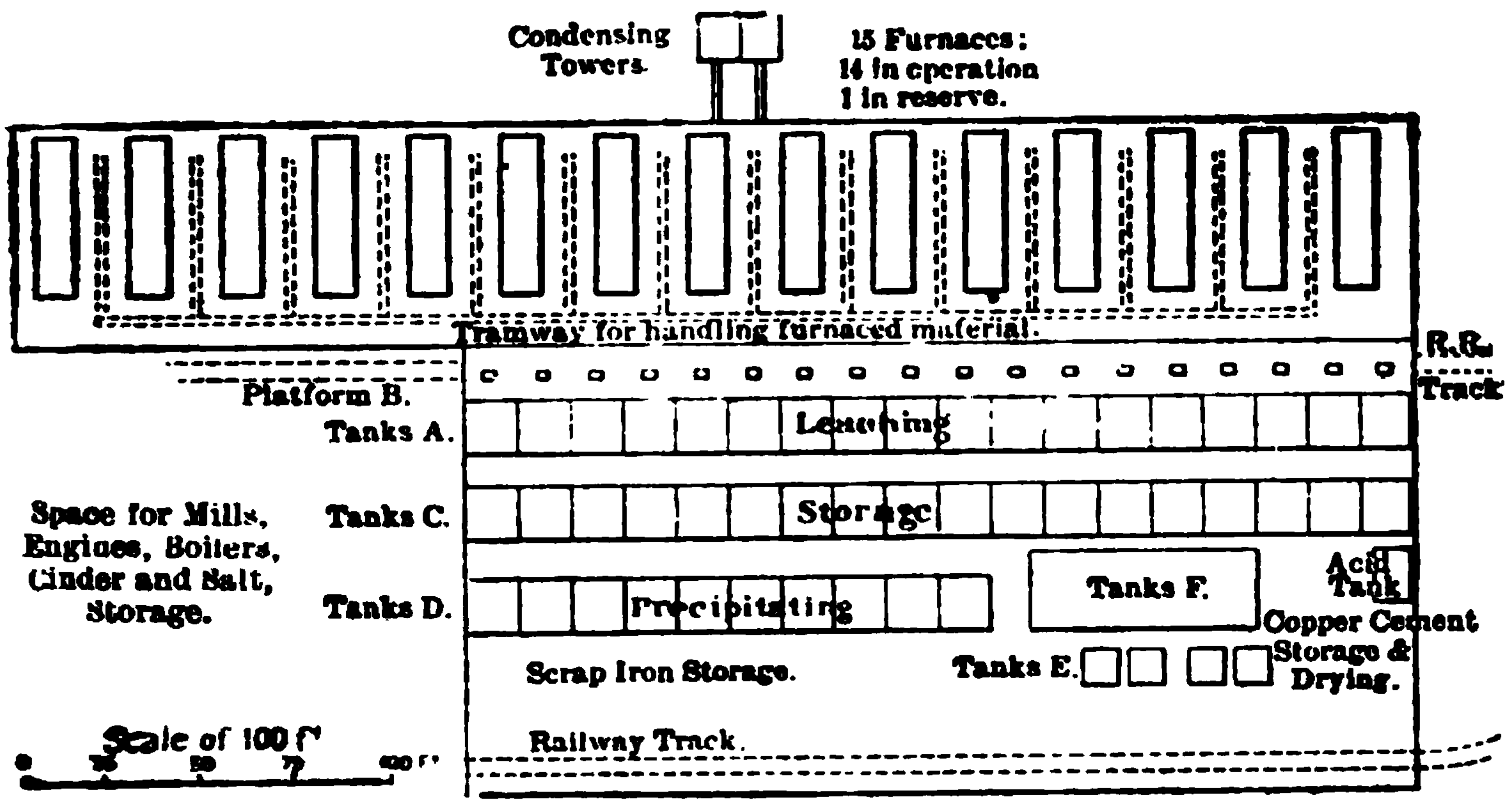


Fig. 2.—General Plan of Leaching Plant, Natrona.

The leaching tanks are eighteen in number, each 14 feet × 4 feet 3 inches deep; the settling and storage tanks, eighteen in number, are each 14 feet × 14 feet and 6 feet 3 inches deep; the precipitation vats, ten in number are each 10 feet × 14 feet and 6 feet 3 inches deep; and the "cement" washing tanks, fourteen in number, are each 10 feet × 10 feet, and 5 feet deep. There is, in addition, a series of tanks for the last precipitation of waste liquors. Space has to be allowed for engines, boilers, cinders, salt, scrap iron, and cement, and for the hoist from muffles to the tanks.

Ex.: At Antwerp, two boilers and an engine furnish 50 N.H.P. to various machines and pumps. There are twnty-four solution tanks, each 82 feet × 11 feet 6 inches and 11 feet 6 inches deep.

It is stated in the "Mineral Industry" for 1893 that the cost of a wet extraction plant is four times that of smelting plant of similar capacity. This is speaking of the Henderson Process in particular. The plant for Neill's or Van Arsdale's Process should not cost more than that of a smelter. The cost of a cyanide plant to treat 1,000 tons a month may be taken, for purposes of comparison, as £2,000.

(*b*) Vats and Tanks.

(i.) *Materials.*—Vats and tanks may be constructed of masonry, iron, or timber, provided that in each case protective materials (cement, lead, red lead, tar, paraffin, clay, &c.) be also used. The disadvantages of masonry are the impossibility of detecting leakages, and, in the case of a subsidence of the foundations, the difficulty in rendering the tanks tight again. By the exercise of the utmost care in construction, however, these give every satisfaction, as at Mount Morgan, where used in the chlorination of gold ores.

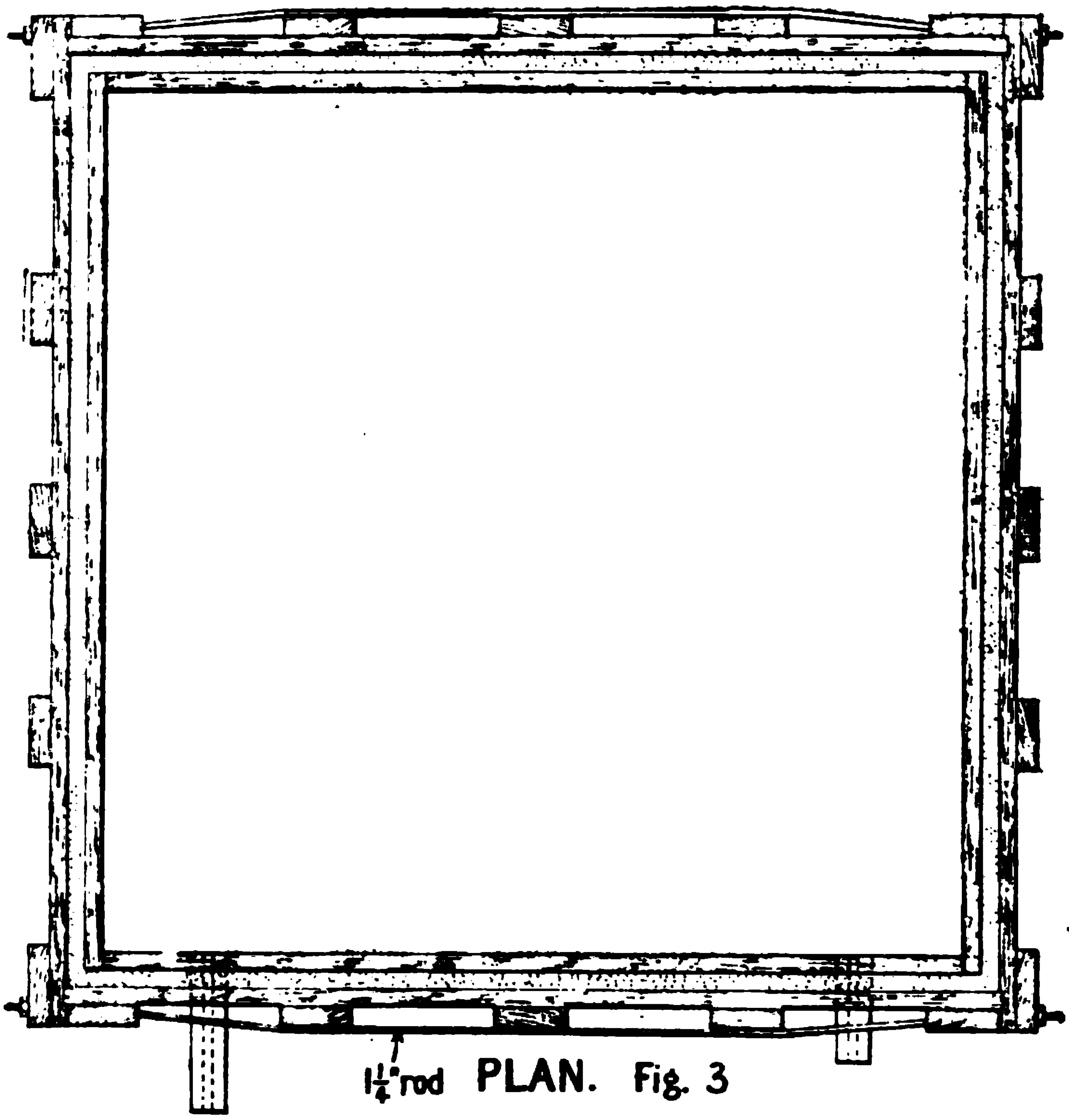
Though iron vats are preferred to wooden ones for cyaniding in the United States, it is probable that the difficulty in protecting iron against the cupreous solutions would necessitate the use of wood or masonry for copper leaching, and the last having been put out of count we must look to timber for the necessary materials.

The corrosive action of the leaching liquors and the consequent heavy repair bill are the main things to be kept in view in designing vats. Wooden pins only may be used, and all supporting timbers, planks, and pins should be tarred on all sides before erection.

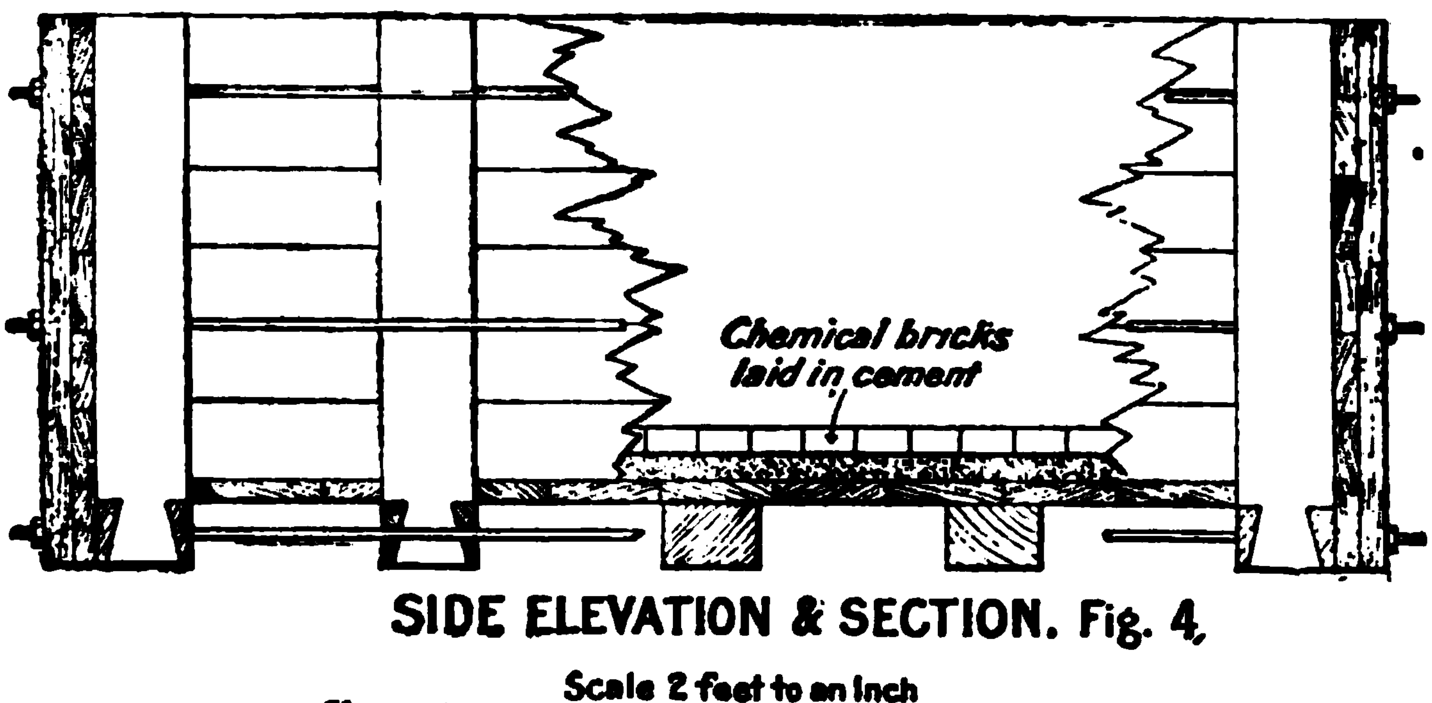
(ii.) *Dimensions.*—Circular vats are preferred to rectangular ones for cyanide work, because of the greater ease in keeping them free from leaks, and because of their greater strength. The sides of tanks, from 14 to 20 feet in diameter and from 4 to 14 feet deep, are constructed of 5 by 2½ inch or 6 by 3 inch planks, while the bottom is made of 12 by 3 inch planks, rebated into the side. The side planks are kept in place by the pressure of ¾ to 1½ inch diameter iron hoops, provided with turn buckles, and placed 15 to 18 inches apart. The cost of a 100-ton vat is £42, and of a 500-ton vat £120.

The comparative weakness of the square vat has to be overcome by greater solidity.

Ex.: At Natrona, the tanks are constructed of outer and inner shells of three-inch plank (tarred inside and out), separated by a space of three inches, which is filled in with a composition of sand and tar. A three-inch layer of the same composition is used on the floor of the tank, and protected from wear by a layer of chemical brick. The solutions are drawn off through six-inch square wooden blocks, bored and provided with plugs. The leaching tanks are 12 feet × 12 feet and 4 feet deep, the settling tanks 12 feet × 12 feet and 6 feet deep, and the precipitating tanks 12 feet × 12 feet and 6 feet deep. In the first, 2-inch × 2-inch wooden slats are laid on the bottom, and covered with hay or coke. The plans given below are taken from an article by Joel G. Clemmer, in Vol. VIII. of "Mineral Industry." The two sides shown without tension rods are supported by adjacent tanks. (*See* Figs. 3 and 4.)



PLAN. Fig. 3



SIDE ELEVATION & SECTION. Fig. 4.

Scale 2 feet to an inch

LEACHING TANK.

Covered vats are recommended for Neill's Process. Those formerly used for chlorination held two to three tons of ore, and were 7½ to 9 feet in diameter and three feet deep. They were built of 2-inch plank, with 2½ by 3¾ inch battens over the joints outside, the whole being covered with three coats of tar. The sides had a batter of 1 in 12.

Cast-iron vats mounted on trunions, so that the contents can be tilted into waste vats, have been used for treating ores of the Black-Warrior Group of Mines in Arizona, U.S.A.

(iii.) *Filters.*—The leaching vats have false bottoms formed of slats, and perforated planks or acid-proof slabs of stone, upon which is a filter of straw, brushwood, or coke.

For cyaniding, frames have superseded sand and gravel beds. They consist of narrow laths one inch apart with transverse laths forming spaces one inch square, and in large vats made in sections. On this frame strong hessian, canvas, cocoa matting, or burlap is used, and kept in position by a rope passing round the circumference of the vat outside the frame.

(c) Foundations.

It is imperative that there shall be free access to the bottom of the vat, whatever the foundation, in order that any leaks may be detected and repaired.

Supports for a 70-ton circular vat, 20 feet in diameter and 7 feet high, consist of horizontal mud sills 15 inches by 6 inches (if a rock outcrop is unavailable), sole pieces 10 by 8 inches, supporting uprights 8 by 8 inches, spaced 4 feet centres, with braces 10 by 8 inches, on which the vat rests.

Steel vats up to 25 feet in diameter and 6 feet high are mounted on wooden foundations, supported 2 feet 6 inches from the ground by 8 by 6 inch bearers, 3 feet centres, resting on 6 by 6 inch uprights, with diagonal braces 4½ by 3 inch. Sills and mudsills are of 8 by 6 inch timber.

At Natrona, the ground beneath the tanks is dug up, and filled in, to a depth of two feet, with concrete, to prevent loss by soakage of the leakage from the tanks; and this also serves as a ground foundation for the timbers.

2.—ROASTING.

The object of roasting is to remove part or all of the sulphur, and as much as possible of the arsenic and antimony.

(a) Heap Roasting.

The disadvantages of heap roasting are the great quantities of fumes polluting the air and the large amount of ore necessarily locked up to produce a given output. Thus, 240-ton heaps, requiring eighty days' treatment, yield only three tons a day, so that 8,000 tons have to be roasting to keep up an output of 100 tons a day.

In selecting a site for the heaps, drainage has to be kept in mind, and the ore is, if possible, to be protected from high winds causing too fierce combustion.

The heap is built in the shape of a truncated pyramid, on a bed of fuel 8 inches to 15 inches thick. The coarser material in the lower and central parts is surrounded by medium-sized ore, and covered by fines. Flues for draught are left in the layer of firewood, and connect with stacks rising through the ore. The height of the heap (from 5 feet 6 inches to 8 feet 6 inches as a rule) varies inversely as the percentage of sulphur in the ore.

The ore is run from the mine on an overhead tramway, and when roasted may be loaded directly into a truck running in a cutting beside the heap.

The cost of heap roasting varies from 2s. to 4s. per ton.

(b) Stall Roasting.

The output may be greatly increased with very little extra cost by roasting in stalls connected with a central stack conveying fumes to the higher air. Each stall may hold 20 tons of ore requiring only ten days to roast, so that the output is two tons per day per stall. Therefore, 1,000 tons roasting in 50 stalls will produce 100 tons a day.

The stalls, $8\frac{1}{2} \times 6\frac{1}{2}$ feet and 6 feet high, are arranged back to back, but separated by the main flue, 2 feet in diameter and 3 feet high, with which they are connected.

(c) Furnace Roasting.

(i.) *Burner.*—Pyrite burners are used almost exclusively in works for the manufacture of sulphuric acid, the object being to obtain the sulphur dioxide free from carbonaceous gases. Little or no carbonaceous fuel is used, and, the process being continuous, only enough air to oxidise the sulphur is admitted. The pyrite layer is 18 inches to 2 feet deep.

(ii.) *Muffle Furnace.*—A plan and elevations are given here from Phillips and Bauerman's "Elements of Metallurgy."

Fig. 5.—Muffle Furnace, Longitudinal Elevation.

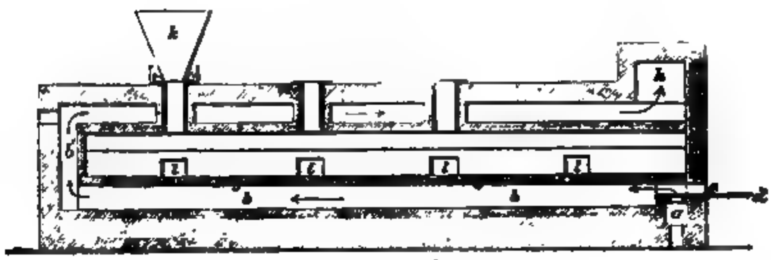


Fig. 6.—Muffle Furnace, Longitudinal Section.

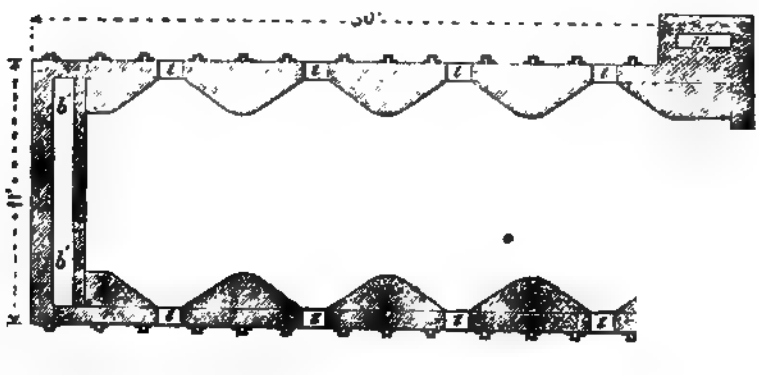


Fig. 7.—Muffle Furnace, Horizontal Section through Working Doors.

FIG. 8.—MUFFLE FURNACE, TRANSVERSE SECTION THROUGH WORKING DOORS.

This is designed for the use of gaseous fuel, but it would require very slight modification for the use of solid fuel. The charge amounts to $3\frac{1}{4}$ tons, and the roast requires six hours.

(iii.) *Hand Reverberatory Calciners.*—These may be either open hearth or muffle. The cost of a reverberatory furnace, putting through 13 tons a day, is £600, and the cost of calcination, reducing the sulphur from 40 per cent. to 7 per cent., is 7s. per ton.

(iv.) *Automatic Calciners.*—Automatic calciners are chiefly used where labour and fuel are dear, their construction and maintenance being costly—

(*a*) Straight hearth: Ex.: "Ohara" and "Spence"; cost of furnace, about £1,200; and cost of calcination, 2s. per ton.

(*b*) Annular hearth: Ex.: "Pearce Turret" and "Horseshoe"; cost of furnace, about £1,100; and cost of calcination, 2s. 3d. per ton.

(v.) *Revolving Cylinders.*—(*a*) Continuous discharge: Ex.: "Howell-White"; used in South Australia and at Mount Morgan. (*b*) Intermittent discharge: Ex.: "Brückner."

(vi.) *Shaft Furnace.*—Ex.: "Hasenclever," a combination of stack and reverberatory furnace used in pyrite burning. The ore falls from side to side down a shaft up which heated gases from the reverberatory pass, and the sulphur being reduced from 10 per cent. to 3 per cent.

3.—WORKING COSTS.

In Vol. II. of the "Mineral Industry" (1893) it is stated, but without further particulars, that the cost of the Henderson Process is 29s. per ton of cinder containing 4 per cent. copper, as against 10s. 6d. by smelting, though the copper saved is as 3.7 is to 3.1. The silver, however, from the wet process has a greater value than that in the matte, and the value of the purple ore residue from the wet process was not considered.

In contradistinction to this, it is stated in Vol. VIII. of the same publication (1899) that the cost by the modification of Henderson's Process used at Natrona, Pennsylvania, is only 7s. $9\frac{1}{2}$d. per ton of ore treated.

Eissler gives the cost of treatment at Rio Tinto at £20 per ton of copper, which is equivalent to 10s. per ton of ore treated.

Ex.: At Rio Tinto, ores yielding only 1½ per cent. copper have been treated at a profit, with the price of copper at £50 a ton.

		£
1 ton of copper is produced from 66⅔ tons of ore—		
Wet treatment for 66⅔ tons of ore at 3s. per ton	... ...	10
Mining, 66⅔ tons of ore at 3s. per ton	... ...	10
Total expenses per ton of copper produced	... ...	20

Leaving a profit of £30 per ton of copper produced, or 9s. per ton of ore treated. These figures are, however, altogether exceptional, and only serve to show what the possibilities are.

The cost of leaching in vats will vary according to the locality, the ore treated, and the size of the plant, and will probably compare with cyanide treatment, which averages about 3s. per ton.

Ex.: At Rio Tinto, the following are the costs by the sulphatising process (Eissler):—

	s.	d.	
Mining	3	2½	per ton ore
Roasting	0	8¼	„ „
Cementation	2	3	„ „
	6	2	„ „

With copper at £50 per ton, a two per cent. ore will yield copper valued at £1, leaving a profit of 13s. 10d. per ton.

Ex.: At Rio Tinto, the following were the costs by the Dotsch process:—

	£	s.	d.	
Lixiviation	3	7	0½	per ton of cement proper
Precipitation	7	4	11	
General Expenses ...	1	2	5	
	£11	14	4½	
Equivalent to	13	16	0	per ton of pure copper,
or	0	3	8	per ton of ore treated.

Ex.: At Natrona, where 200 tons of ore and salt are treated daily, the cost of treatment is £70 9s. 4d., equivalent to 7s. 11d. per ton of pyrite. The men employed include: two engineers, one mechanic, three firemen, two samplers, and six mill men: four weigh-men and furnace charges, twenty-eight furnace men, one hoist man, twenty-seven furnace material handlers and wheelers, two leachers, and four copper precipitators.

Ex.: At Antwerp, 96 tons of ore and 24 tons of salt are put through per twenty-four hours, at a cost of £1 6s. 8d. per ton of ore, which is bought for 3s. 4d. per ton. Ninety-six tons of ore produce three tons "cement" (equivalent to 2·47 tons copper), valued at £160 10s. with copper at £65.

Expenses of treating, £128; total profit, £32 10s.; and profit per ton of ore, 6s. 8d.

The employees include: one general manager, three superior officials, ten overseers, mechanics, blacksmiths, and carpenters; twelve men in crushing department; twenty-eight men at roasting furnaces; twelve men at precipitation vats; ten chargers; eight loaders of purple ore; sixteen maintaining material; and forty-three general hands. Total, 143.

VII.—Summary.

BRIEF DESCRIPTION OF COMPLETE PROCESSES.

1.—Atmospheric Oxidation.

(Rio Tinto.)

Sulphides are exposed in heaps, leached with water and iron sulphate liquors (from the precipitation vats), and the copper precipitated in vats by iron.

2.—Slow Roast.

The process is the same as No. 1, except that the heaps are roasted before leaching.

3.—Ferrous Sulphate Roast.

Differs from the above (No. 2) only in that ore is roasted with ferrous sulphate.

4.—Neill's Process.

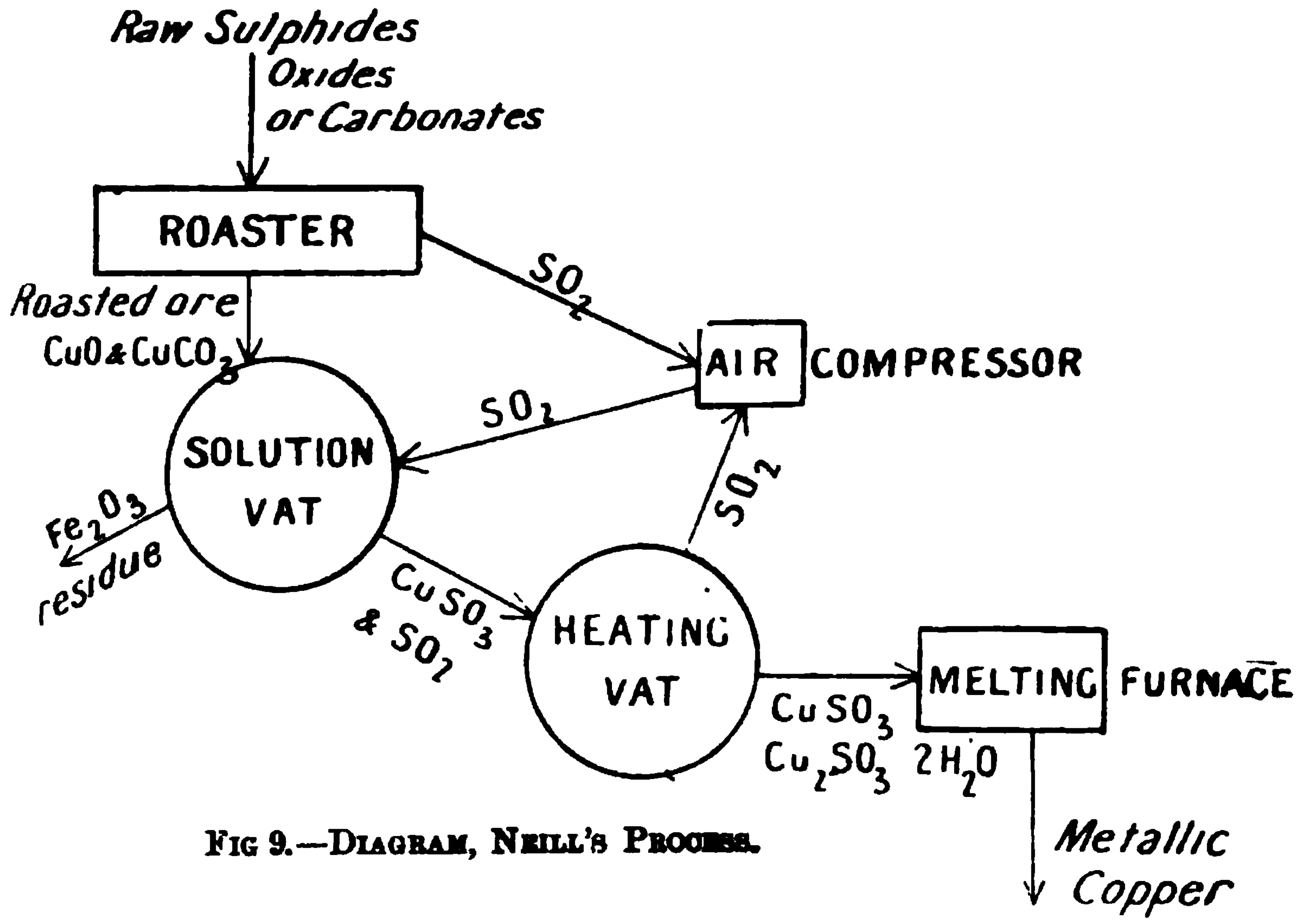


Fig 9.—Diagram, Neill's Process.

5.—Henderson's Process.

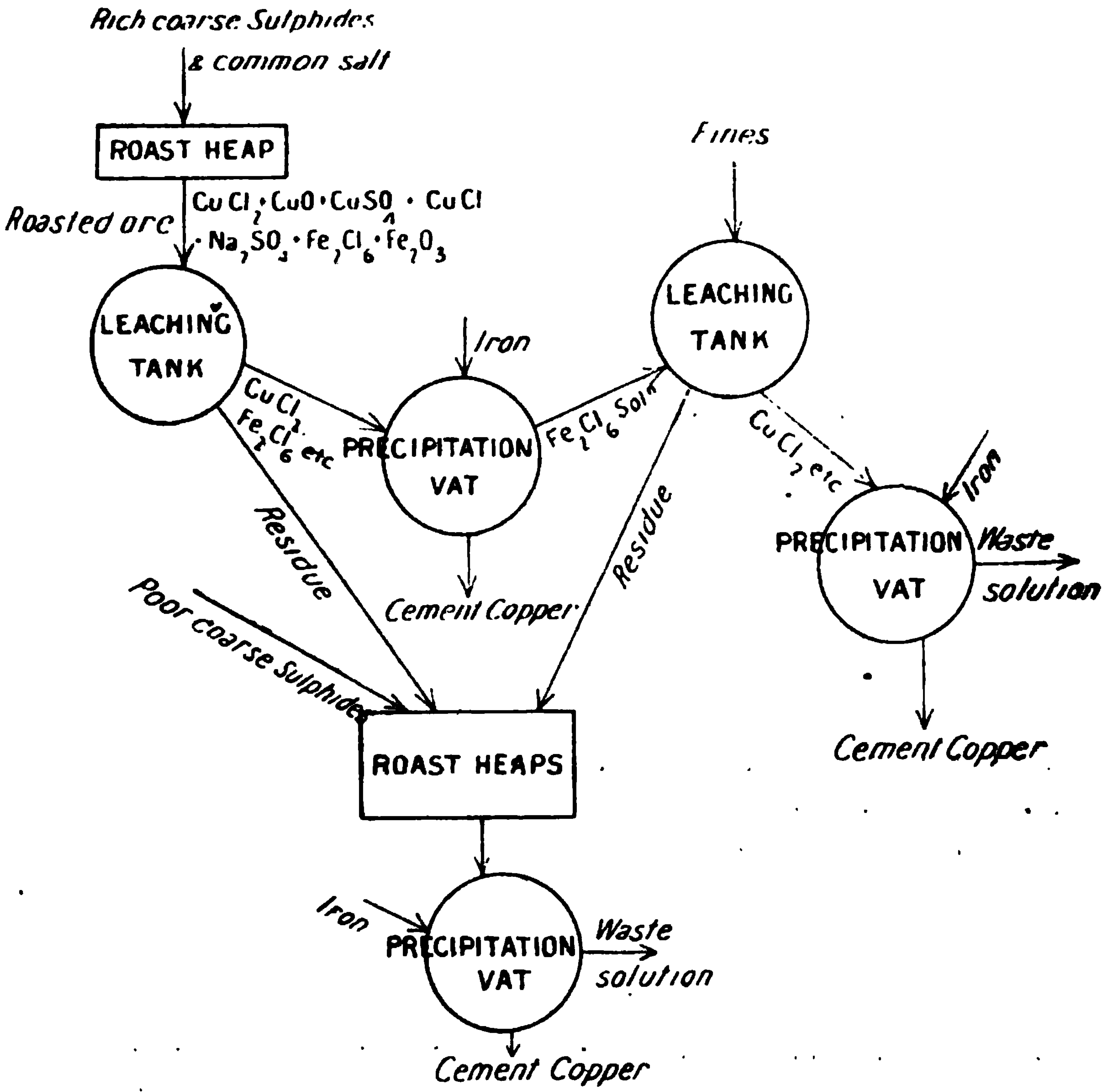


Fig. 10.—Diagram, Henderson's Process, as practised at Rio Tinto.

Modification (Rio Tinto).—Residues from sulphuric acid manufacture are roasted with common salt; the chlorides, oxides, and sulphate are then leached out with water and acid liquors from the precipitation tanks. The sulphide-bearing residue is allowed to oxidise while covered with sulphides mixed with common salt and manganese dioxide to produce copper chlorides, which are reduced with iron.

Modification (Rio Tinto).—The ferric chloride from the roast heaps is used for leaching the sulphide fines, forming cupric chloride, which, after the solutions have settled, is precipitated in the ordinary way.

Modification (Oker).—Sulphides, after an oxidising roast in pyrites burners, are further roasted with common salt in a gas furnace: the chlorides and sulphate are leached out with water in vats, and the copper precipitated in separate vats by metallic iron.

Modification (Antwerp).—Sulphide fines are roasted with common salt in a muffle furnace, and the sulphurous and chlorine gases given off, after condensation and absorption by water in a tower, are used for leaching together with the acid liquors from the precipitation vats. The cupric chloride is reduced by iron.

Modification (Natrona).—The burnt pyrite is roasted with common salt in a muffle furnace, and leached in vats with water, and the condensed gases given off during the roast. Precipitation from the cupric chloride is by iron.

Modification (Combination with Claudet Process).—The silver in solutions from the leaching vats is precipitated by the addition of zinc iodide, and the copper, free of silver, is then reduced from the chloride solutions with iron.

Modification (Dotsch Process).—The pyrite fines are leached in heaps with ferric sulphate and common salt and ferric chloride (produced by the action of chlorine on ferrous chloride). Precipitation is by iron, ferrous chloride being formed at the same time.

6.—Sulphuric Acid Process.

(Stadtberge.)

Carbonate ores are leached in tanks with acid formed by the combination of water, sulphur dioxide (from pyrites burners), and nitrous oxides (from a nitre furnace), together with the acid liquors from the precipitation tank, where copper is reduced by iron.

7.—Hydrochloric Acid Process.

(Stadtberge.)

Agrees with the sulphuric acid process in all except that hydrochloric acid replaces sulphuric, and that the silver is precipitated on the first of the copper throw down, and is thereby saved.

8.—Old Hunt and Douglas Process.

Oxidised ore, after a heap roast, is agitated with ferrous chloride, produced by mixing ferrous sulphate and common salt, and also by precipitation of the copper by iron.

9.—New Hunt and Douglas Process.

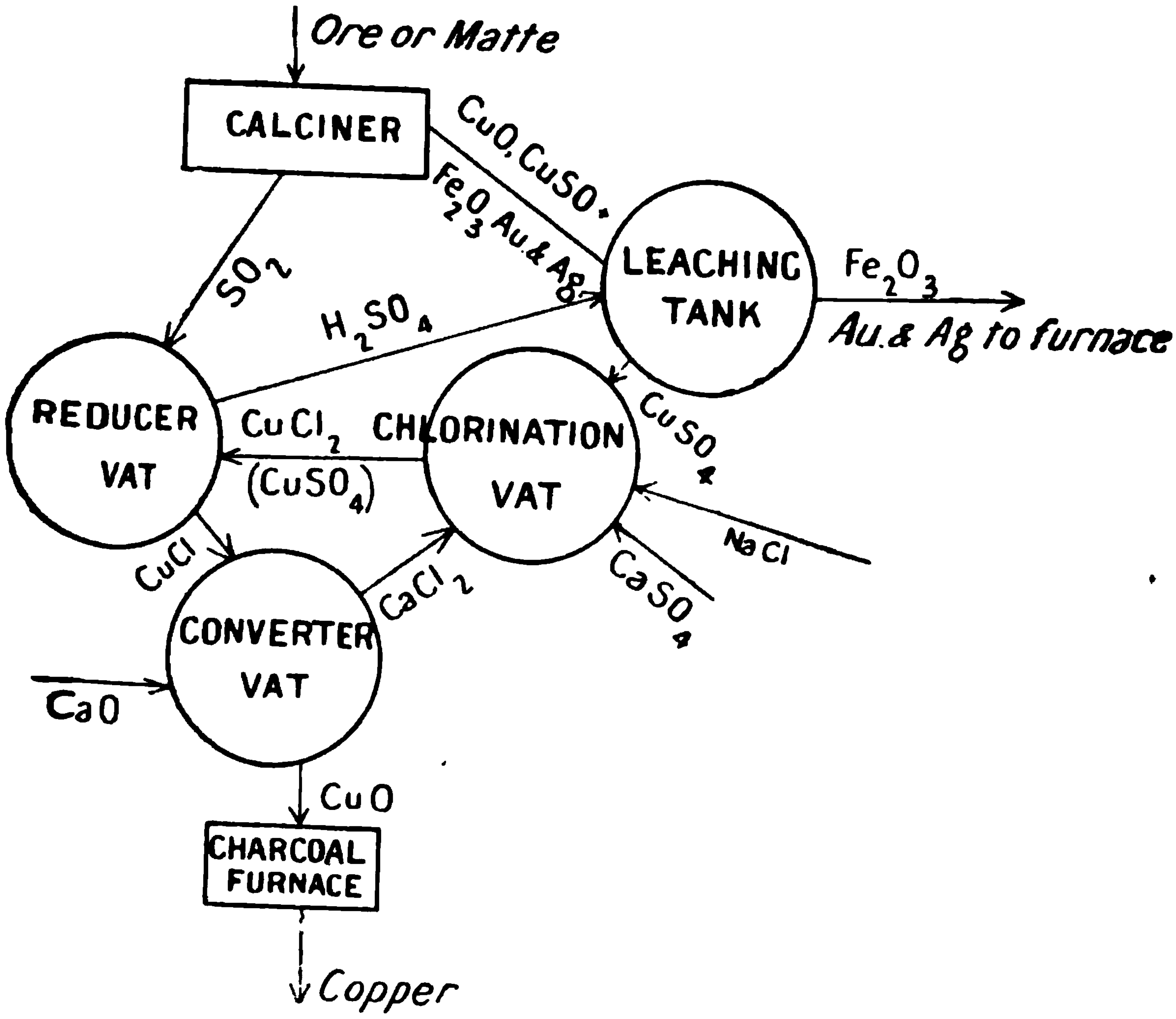


Fig. 11.—Diagram, New Hunt and Douglas Process.

10.—Van Arsdale's Process.

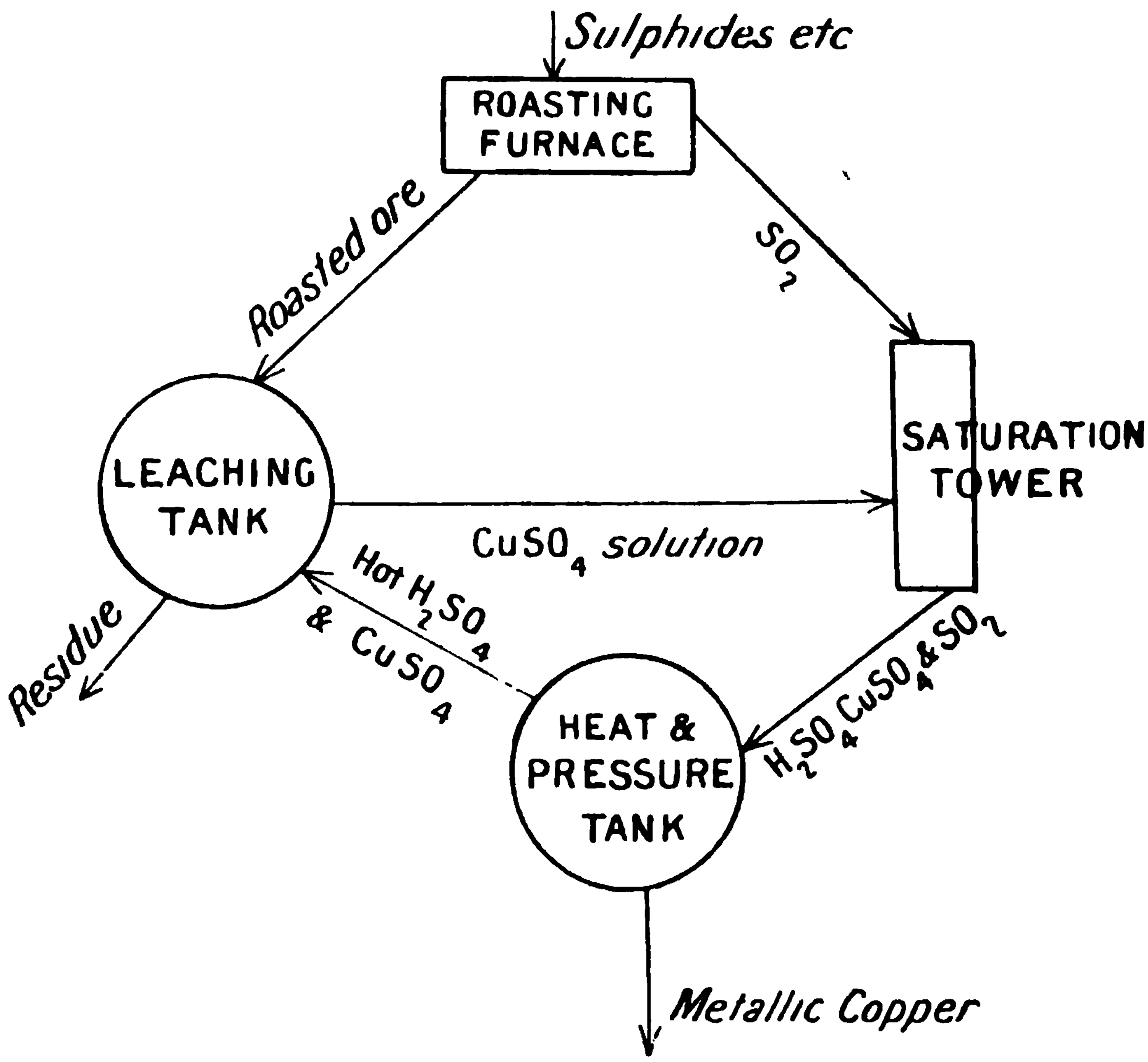


Fig. 12.—Diagram, Van Arsdale's Process.

VIII.—Electrolytic Extraction from the Ore.

There are two processes (Siemens-Halske's and Hoepfner's) available for the electrolytic extraction of copper from its ores, but nothing has yet been proved as to their working on a commercial scale. Important results have been obtained in the refining of the metal, but it is held that even in that case electrolytic methods should only be considered when precious metals are at the same time saved, and a high price is obtained for the refined copper.

1.—Copper Sulphate Solution.

(Siemens-Halske Process.)

The copper sulphide is dissolved by a solution of ferric sulphate containing free sulphuric acid. The anode of carbon and the cathode of sheet copper are separated by a diaphragm previous to the solutions.

2.—Copper Chloride Solution.

(Hoepfner's Process.)

The chlorides are dissolved and held in solution by common salt or calcium chloride, and separate solutions are delivered to a series of carbon anodes and copper cathodes (on which copper is deposited), separated by diaphragms.

By Authority: George Arthur Vaughan, Government Printer, William street, Brisbane.

Queensland.

DEPARTMENT OF MINES.

GEOLOGICAL SURVEY OF QUEENSLAND.
Publication No. 194.

REPORT.

CERTAIN IRON ORE, MANGANESE ORE, AND LIMESTONE DEPOSITS

IN THE

Central and Southern Districts of Queensland.

(WITH 27 MAPS AND PLANS AND 16 PLATES.)

Page vii., line 53, *for* "Plate 5," *read* "Plate 14."

Page 21, line 37, *for* "glanconitic," *read* "glauconitic."

Page 22, Map 11, In reference—
After "Ipswich Beds," *read* "Upper Trias-Jura."
After "Burrum Beds," *read* "Lower Trias-Jura."
After "Desert Sandstone," *read* "Upper Cretaceous."

Page 25, line 30, *for* "*See* Map 6," *read* "*See* Plan 13."

Plate opposite page 40, *for* "Plate 5," *read* "Plate 14."

Page 66, line 14, *for* "eastern at," *read* "eastern and."

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By LIONEL C. BALL, B.E.,
ASSISTANT GOVERNMENT GEOLOGIST.

BRISBANE:
:THORITY: GEORGE ARTHUR VAUGHAN, GOVERNMENT PRINTER, WILLIAM STREET.

1904.

LETTER OF TRANSMITTAL.

Geological Survey Office,
Brisbane, 12th May, 1904.

SIR,—I have the honour to forward for publication a report by Mr. L. C. Ball on "Certain Iron Ore, Manganese Ore, and Limestone Deposits in the Central and Southern Districts of Queensland."

The work entailed in the preparation of the report has extended over many months, and a great number of localities have been inspected with the view of obtaining all necessary information. Much more requires to be done, however, in the Northern districts of the State, and it is to be hoped, in view of its importance, that facilities will be granted to have the work completed later on.

A Royal Commission was appointed by the Governor-General to report on the Bonuses to Manufacturers Bill, and three sittings were held in Brisbane on 1st and 2nd May, 1903. Evidence was given on the occurrence of deposits of ores of iron, chromium, wolfram, molybdenum, coal, and of limestone, and the witnesses examined were Captain Richards, of Mount Morgan, Mr. W. Fryar (Chief Inspector of Mines), Mr. J. Hargreaves (mining surveyor), Mr. L. C. Ball, and myself.*

The whole of the evidence showed conclusively that Queensland has vast resources in the raw material required for iron and steel manufacture, and in this Report—so far as iron, manganese, and limestone in the Central and Southern districts are concerned—Mr. Ball has given the details of what, at that inquiry, was only shown in outline.

I have, &c.,
B. DUNSTAN,
Acting Government Geologist.

The Under Secretary for Mines,
Department of Mines, Brisbane.

* The Parliament of the Commonwealth of Australia. Report from the Royal Commission on the Manufacturers Bill, together with the Proceedings, Minutes of Evidence, and Appendices. Fcap. By Auth.: Melbourne, 1904; p.p. 194.

CONTENTS.

I.—ROCKHAMPTON DISTRICT.

II.—GLADSTONE DISTRICT.

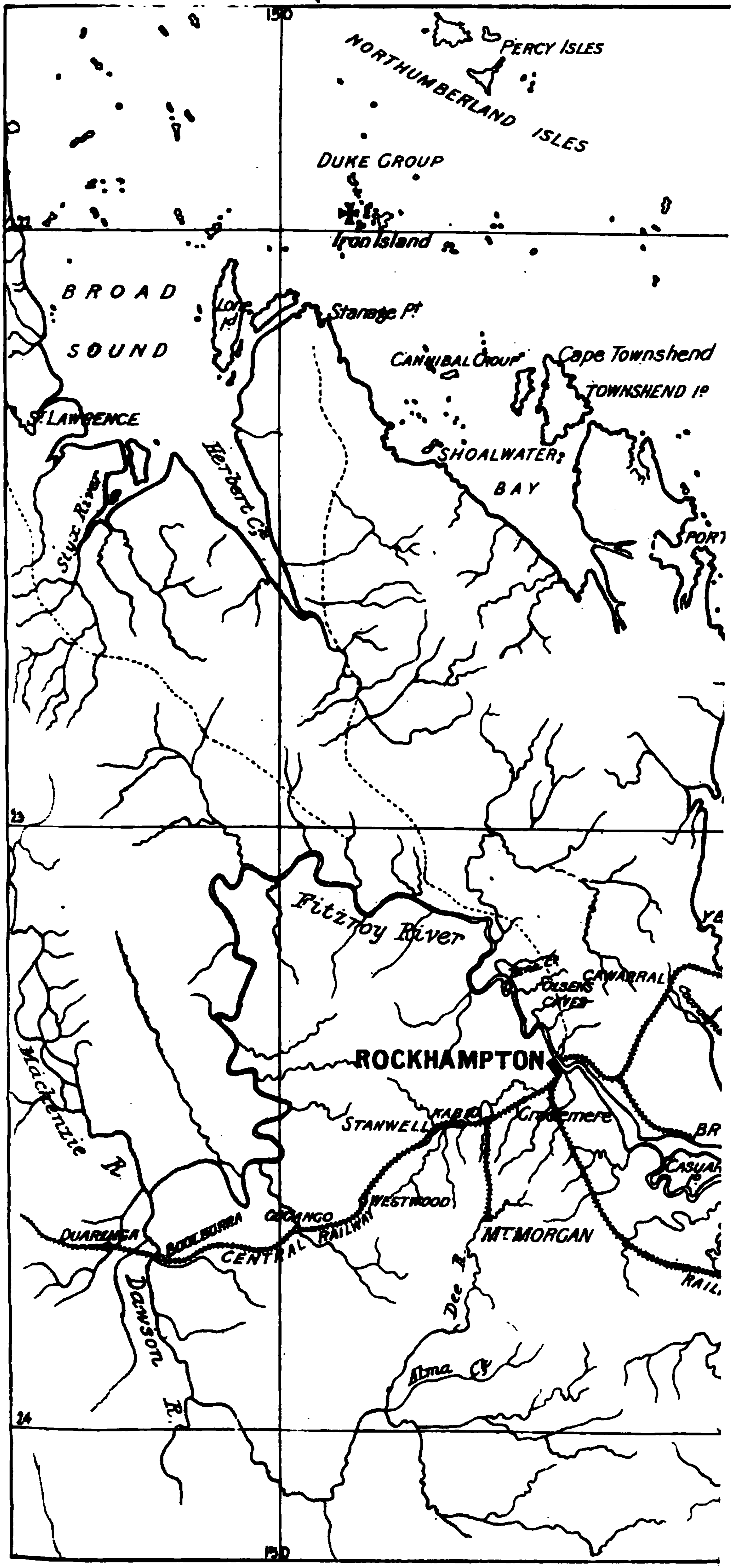
III.—MARYBOROUGH DISTRICT.

IV.—IPSWICH DISTRICT.

V.—DARLING DOWNS DISTRICT.

FIGURES.

GEOLOGICAL SURVEY OF QUEENSLAND



EOLOGICAL SURVEY of QUEENSLAND

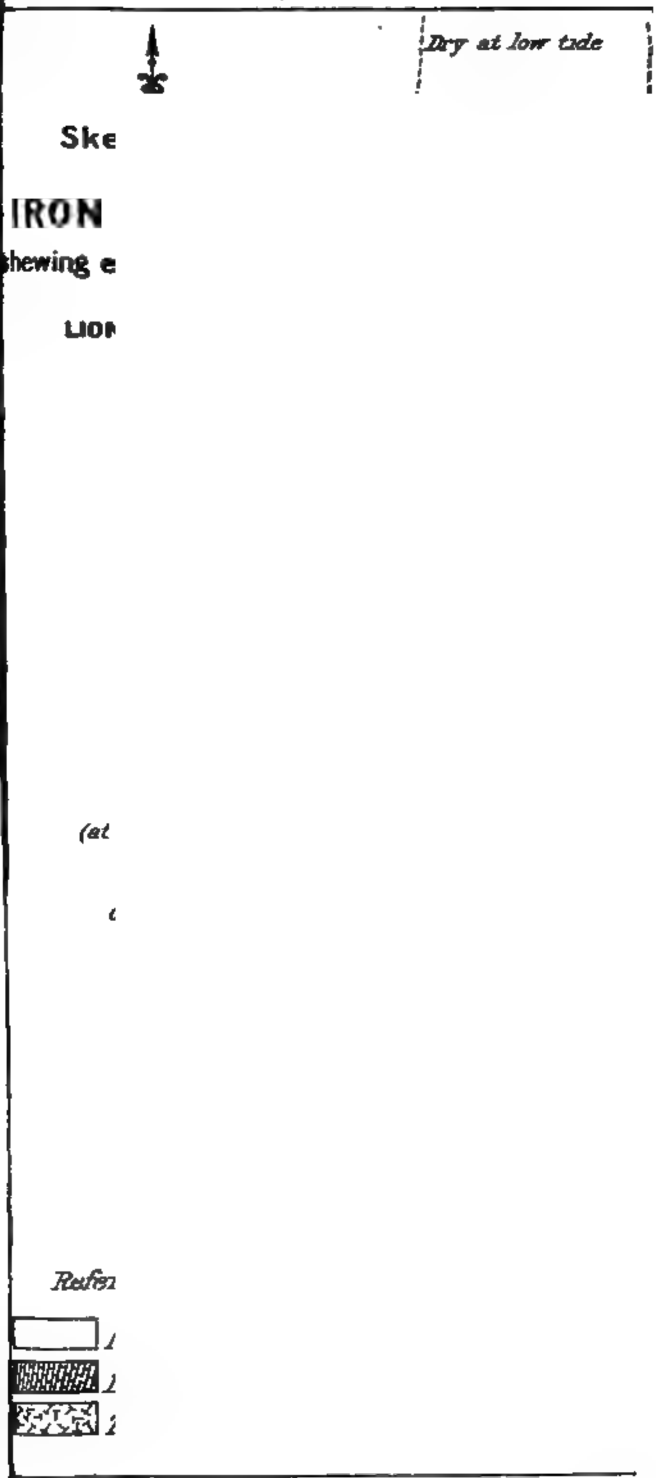


Plate 1 a.

Photo., L.C.B.

IRON ISLAND.
(*Viewed from the East.*)

Plate 1 b.

Photo., L.C.B.

BLOCK OF MAGNETITE WITH THE STRUCTURE OF SLATE, IRON ISLAND.

CERTAIN IRON ORE, MANGANESE ORE, AND LIMESTONE DEPOSITS IN THE CENTRAL AND SOUTHERN DISTRICTS OF QUEENSLAND.

I.—ROCKHAMPTON DISTRICT.

A—Iron Ore Deposits.

The deposits in the Central District were hurriedly inspected with a view to giving information to the Iron Bonus Commission sitting at the time, and it will therefore be necessary for more detailed work to be done as time permits, at least in the case of Iron Island and the Dee River deposits.

It has been considered advisable in describing the deposits to work from north to south, and in that order the descriptions will be found in the following pages. (*See* Locality Map 1.)

I.—IRON ISLAND.

Locality.—Iron Island, one of the smallest of the Duke Group in the Northumberland Islands, is about forty miles north-east of St. Lawrence, and midway between Rockhampton and Mackay. It lies just south of the north-western headland of Marble Island, with which it is connected at low tide. There is deep water on the south, south-east, and south-west, and an anchorage in five fathoms between it and Marble Island on the south-east. (*See* Plan 2 and Plate 1A.)

The island is now held as a mineral lease at a yearly rental of 10s. per acre. No previous official report has been made on the island, but Dr. Jack, in a map accompanying a "Report* on the Geological Features of the Mackay District," 1887, shows rich hæmatite on Iron Island. He paid a brief visit to the Duke Group, and described the limestones. Owing to the very brief time spent here, the present report must be looked upon as only preliminary.

Extent.—The island is 20 chains in greatest length and eight chains in greatest width, and the whole, except a strip of one to two chains wide on the west and a sand flat five chains across on the north, is iron ore. The highest point of the island is 120 feet above high-water mark.

Taking the specific gravity of the ore as 4.5, there will be 3.4 tons per cubic yard, and the amount of ore above high-water mark will be 1½ million tons. The additional ore between the tides (23 feet) will amount to three-quarters of a million tons, making a total of 2¼ million tons of available ore.

It is, of course, possible that there may be slate in the interior of the hill, but that can only be proved by adits or shafts.

Geology.—The rock on the western side of the island is greenish, highly-altered trachyte, in which there has been a great development of east and west

* G.S.Q. Publication No. 39.

cross quartz veins, probably formed before the iron was introduced into the adjacent country. On the south side of the island are three outcrops of pure white statuary marble, from 10 to 20 feet across and from 20 feet to a chain in length. The ore has, in my opinion, metasomatically replaced limestone and slate (*see* Plate 1B), and the formation of ore may be still going on, for the ridge top supports figs and scrub vegetation, showing that spring water is still reaching the surface. The ore may, therefore, be expected to continue to some depth.

Ore.—The ore consists in greater part of cryptocrystalline magnetite, with massive hæmatite, and scarcely a trace of visible impurity. Its specific gravity is 4.5 to 4.6. Blocks of ore up to 10 feet in diameter, weathering with every appearance of slate, are piled up round the base of the island, as seen in the accompanying photographs. (Plates 2 and 3.)

A rough surface sample was taken from the whole of the iron ore area, and its analysis is given below, together with that of a single specimen from the south side of the island.

	Sample (Mount Morgan Co.'s Analyst).*	Specimen (Government Analyst).
Water	0.13	0.46
Silica	2.51	1.73
Alumina	2.95	2.71
Iron	64.72 equivalent magnetite 89.73	63.94 equivalent hæmatite 91.34
Manganese	—	—
Lime	2.85	5.53
Magnesia	1.07	trace
Phosphorus	0.065	trace
Titania	—	—

These show the silica to be phenomenally low. The phosphorous is, however, too high (in the sample) for the Acid-Bessemer process, but it must be remembered that this is a general sample. On thoroughly sampling the whole island it would probably be possible to eliminate the phosphoric portion. The Lake Superior ores range from 0.009 to 0.067 per cent. phosphorus, so that a separation has to be made even there. The percentage might be reduced by mixing with other ores low in phosphorus.

Workings.—No work has yet been done on the island. There will be no difficulty in working down to tide level, but to work below, a wall of ore would have to be left to prevent the entrance of the sea water.

Treatment.—On Marble Island there is plenty of room for the erection of furnaces to which the ore could be conveyed by way of a viaduct across the channel between the two islands.

Either coal or coke might be brought there from Rockhampton, Burrum, or Ipswich, necessitating carriage by train of 90, 18, and 22 miles, and by boat of 150, 300, and 500 miles respectively. Were the cokes equal in quality it would be therefore cheaper to obtain supplies from the Burrum or else from Ipswich.

Alternative sites that have been suggested for furnaces are St. Lawrence, Broadmount, Port Alma, and Gladstone.

On the Styx River (St. Lawrence) Coal Field, which covers an area of 156

* Advantage was taken of Captain Richards' disinterested offer to have the analyses made at the Mount Morgan works because of the necessity of having them done immediately.

Plate 2.

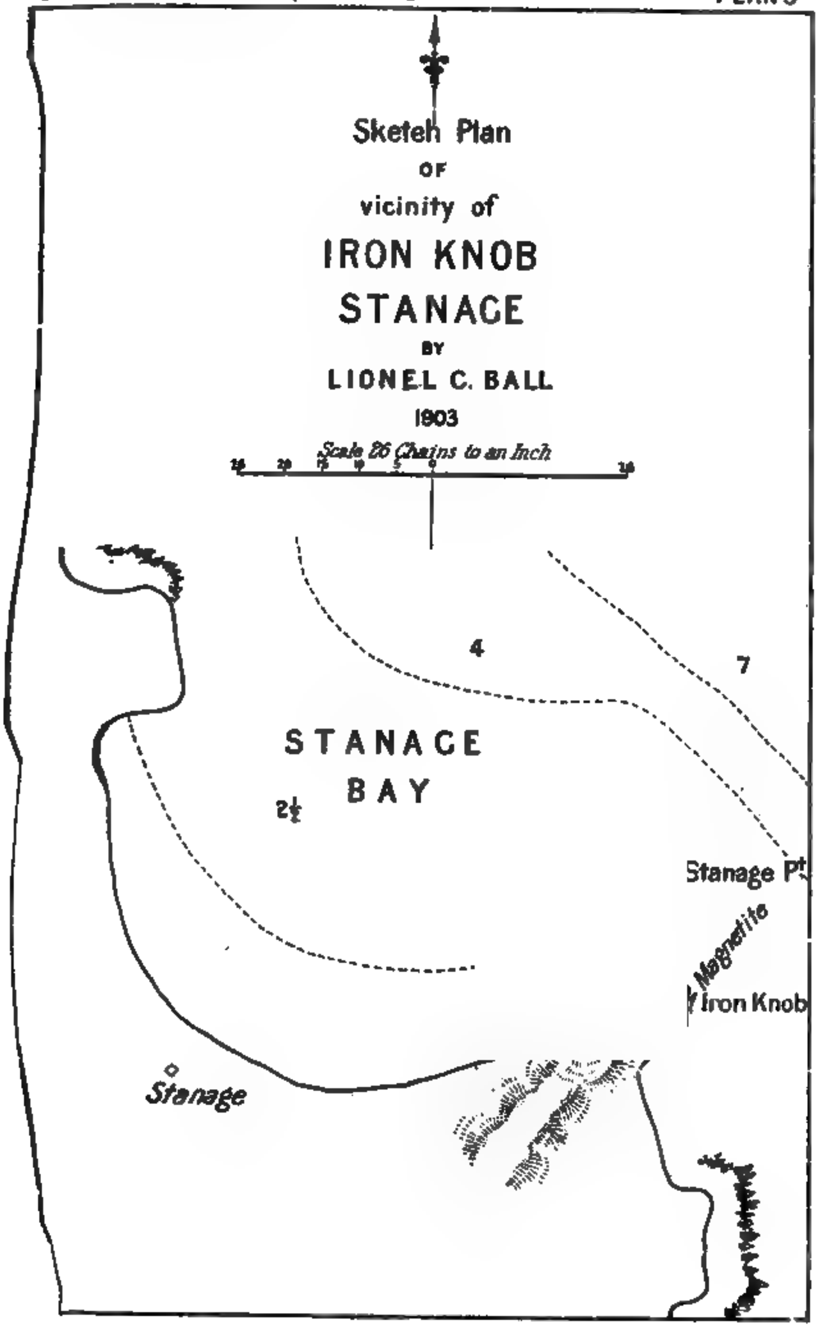
Photo., L.C.B.

IRON ORE TALUS, ABOVE TIDES, SOUTH EASTERN END IRON ISLAND.
(*Marble Island in the distance.*)

Plate 3.

Photo., L.C.B.

Iron Ore Shingle, between Tides, South-eastern End Iron Island.


Sketch Plan
OF
vicinity of
IRON KNOB
STANAGE
BY
LIONEL C. BALL
1903
Scale 26 Chains to an Inch
4
7
STANAGE
BAY
2½
Stanage Pt.
Magnetite
Iron Knob
Stanage

square miles, there are several small seams, and one, at Waverley Creek, showing 4 feet 11 inches coal and two bands amounting to two feet. The coal contains:

Water	... ...	2.3	per cent.
Vol. Hydrocarbons	...	22.89	„
Fixed Carbon	...	63.11	„
Sulphur	.. ...	0.55	„
Ash	... ...	10.78	„

but it does not appear to coke.* The workings are some eight miles from Broad Sound, and the distance from Iron Island is 60 miles. There is difficulty in navigating this part of the coast owing to the shoals.

Broadmount, at the mouth of the Fitzroy River, 150 miles from Iron Island, is already connected by rail with the Central District Coalfields, whence either coke or semi-anthracitic coal could be brought. This would, however, require a train journey of at least 100 miles. The coal has hitherto been believed to be wholly semi-anthracitic in character, but quite lately certain seams have been proved to yield coking coals. The following is a typical analysis of coal hitherto raised† :—

Water	... ...	3.75	per cent.
Vol. Hydrocarbons	...	12.98	„
Fixed Carbon	...	78.45	„
Sulphur	... ...	trace	
Ash	... ...	4.84	„

Manganese ore occurs at Cooroomam (27 miles distant by rail), and limestone could be brought in tugs from 20 miles up the river, where there are large beds, or else from the immense deposits on Raglan Creek, 20 miles to the south.

Port Alma might be connected with both Rockhampton and Gladstone; but it is understood that it is difficult, if not impossible, to obtain foundations in the alluvial, and the erection of furnaces near the wharves is therefore not practicable.

At Gladstone, on Port Curtis, there are besides immense supplies of limestone (20 miles up the Calliope River), manganese, and a certain amount of iron ore, and it has been proposed to construct a railway to the Callide Coal Field, whence coal could be brought. It has not been proved that this is a coking coal, though there is probably coal that will coke on the field.

II.—STANAGE.

Locality.—Stanage Point is near the northern extremity of the large peninsula (county of Palmerston), lying midway between Rockhampton and Mackay. The nearest town is St. Lawrence, which lies $37\frac{1}{2}$ miles distant to the west-south-west across Broad Sound. Stanage Bay, to the north of the point, gives an anchorage ($2\frac{1}{2}$ fathoms) in fair weather. Sufficiently deep water ($2\frac{1}{2}$ fathoms) for loading reaches close up to the shore at the mine. (*See* Plan 3.)

Iron Knob, as the deposit is called, rises to a height of 30 feet directly from the beach on the eastern side of Bald Hill.

---

* Report on the Styx River Coal Field. By W. H. Rands. Bris.: By Auth., 1892. G.S.Q.P., No. 84.

† Report on the Geology of the Dawson and Mackenzie Rivers, &c. By B. Dunstan. Bris.: By Auth., 1901. G.S.Q.P., No. 155.

Dimensions.—The width of ore varies between six and ten feet for a distance of 50 feet, and it can be traced for a further distance of 25 yards to the south.

Ore.—On the surface the ore is black pulverulent magnetite, with a certain amount of hæmatite, and its specific gravity is 4.5. It is somewhat veined by quartz, and contains a small amount of copper ore in scattered bunches, probably less than two per cent. even in the richest places. In these bunches the chalcopyrite occurs as fine threads and grains, gradually fading into the magnetite.

An analysis (Mount Morgan analyst) of a surface sample of the ore gives:—

Iron	60 per cent.
Phosphorus	Nil.

The ore from a depth is massive, has a purplish tint, and is freer than the surface stone from quartz veins. That from the underlie shaft mentioned below contains veins of greenish magnesian silicate, usually seen in altered slate, and on fractures a thin layer of mammilated hyalite is often developed, especially where there is a trace of chalcopyrite.

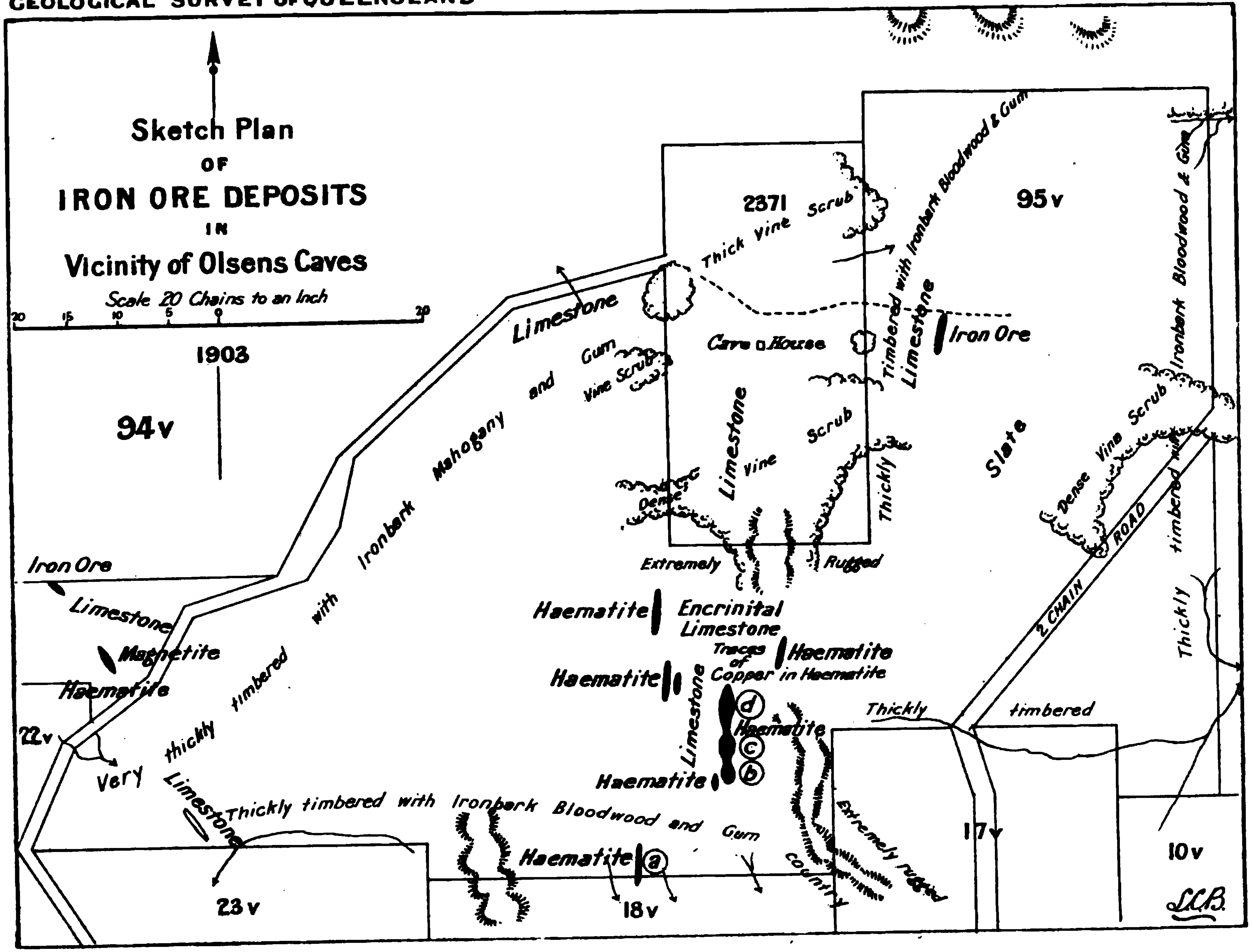
The limit of the deposit is well-defined on the west, but the country on the east is veined and laminated with ore for a few feet; and, as specimens can be obtained both from the shafts and the surface showing indistinctly the structure of slate, it may be taken that the ore has replaced quartz-veined country, probably on the eastern side of a fissure. The main portion of the lode strikes north-north-east, and seems to cross the bedding of the country, but the remainder bends round almost to north and south.

An estimate, necessarily rough, of the amount of ore above a depth of 100 feet is 7,000 tons.

Country.—The immediate country rock is greenish tuff slate and conglomerate, while further west is an ordinary clay slate. Blocks of marble occur on the beach but the bed itself is not visible. The country rock east of the deposit is veined with quartz in a similar manner to the ore; this quartz contains no cavities except where spangles and bunches of chlorite have weathered out from it. The country rock at a depth consists of impure limestone, and it is this chiefly that the iron ore has replaced. The less pure parts of this limestone have been altered into a greenish schist with disseminated crystals of calcite. The limestone, like the slates, is veined with crystalline white quartz containing bunches of chlorite, and in addition, radiating crystals of epidote. The formation of nodules of garnet can also be seen in places. Evidently there has been great regional metamorphism here, causing rearrangement and segregation of certain of the mineral constituents of the rocks, and the production of a schistose structure. My opinion is that the iron has been introduced subsequently, probably owing to a deep-seated intrusion, and precipitation has been caused by the limestones.

Workings.—This deposit was worked thirty years ago for copper. A shaft was then sunk on the seaward side of the Knob, in the hope that the amount of copper would increase with depth. The ground then lay abandoned till 1902, when it was again taken up and the shaft continued to a depth of 90 feet. It was then abandoned, probably because of the entrance of sea water, and an underlie shaft was sunk to 100 feet depth at the foot of the cliff, a chain from the first shaft. Both shafts are now full of water.

Conclusion.—This deposit is of importance in connection with that at Iron Island, its composition being in direct contrast to that at the latter place. It also points to the possibility of other deposits being found along this coast, and in fact another has been reported to exist on Long Island, in Broad Sound.


Sketch Plan
OF
IRON ORE DEPOSITS
IN
Vicinity of Olsens Caves
Scale 20 Chains to an Inch
20 15 10 5 0 20
1903
94v
95v
2371
Thick vine Scrub
Timbered with Ironbark Bloodwood & Gum
Ironbark Bloodwood & Gum
Limestone
Iron Ore
Cave House
Limestone
Vine
Scrub
Thickly
Slate
Dense Vine Scrub
thickly timbered with
2 CHAIN ROAD
Thickly
Gum
Vine Scrub
Ironbark Mahogany and
Dense
Extremely Rugged
Haematite
Encrinital Limestone
Traces of Copper in Haematite
Haematite
Limestone
Haematite
Haematite
Iron Ore
Limestone
Magnetite
Haematite
22v
Very thickly timbered with
Limestone
Thickly timbered with Ironbark Bloodwood and Gum
Haematite
18v
23v
Extremely rugged country
Thickly timbered
17v
10v
L.C.B.

III.—OLSEN'S CAVES.

(*a*) PORTION 95V, FITZROY.

Locality.—The main outcrops of iron ore in the vicinity of Olsen's Caves are on portion 95v, Fitzroy, 14 miles north-north-west of Rockhampton, and 5½ miles north-east of the nearest point of the Fitzroy River, which is there navigable for small boats. The road to the river has a down grade all the way.

Extent.—There are five outcrops from one to five chains in length and from two feet to two chains across, formed of boulders up to 10 feet in diameter. The main bodies lie on north and south lines, between portions 2371 and 18v. Owing to the thick grass at the time of my visit it was difficult to determine the extent of the deposits, but it is believed that the areas shown have not been exaggerated. (*See* Plan 4.)

Taking the depth of the deposits as equal to one-half the length, and only considering the three main ones shown on the plan (marked b, c, and d), which are two, two, and four chains long and two, one, and one-third chain wide, the amount of ore here is over one-quarter of a million tons.

Ore.—The ore consists of massive hæmatite and magnetite (specific gravity 4.8), with scarcely any visible impurity, except a little quartz in cracks far apart. A sample from the eastern line of outcrops (that marked b, c, d) assays (Mount Morgan):—

Iron	...	...	67 per cent.
Phosphorus	...	...	trace

Another from the western line yields (Mount Morgan):—

Iron	...	...	73 per cent.
Phosphorus	...	...	nil.

(This result is slightly higher than that necessary for pure magnetite.)

The ore is thus specially suited for the Acid-Bessemer process and of value for mixing with phosphoric ores, such as that on Iron Island, to render them low enough in phosphorus to be treated by the same process.

Geology.—That the ore here replaces limestone is proved by specimens showing the partial replacement, and besides where the ore can be seen in contact with limestone veins, and branches of the former pass into the latter. Nothing more definite can be said as to the origin of the deposits. They may be contact deposits of the Christiania type, as their position on the edge of the limestone indicates; but so little could be seen owing to the grass that this cannot be affirmed. No contact minerals were found there. The country rocks consist of slates and limestones, but as no fossils have been found in them their age is unknown. Devonian strata occur some miles to the south (at Raglan), and may be connected with them.

(*b*) PORTION 22V, FITZROY.

Locality.—Crown land, north-east of portion 22v, Fitzroy, three-quarters of a mile west of the above described deposits.

Extent.—The outcrop was followed in a north-westerly direction for two chains, its width varying from five feet to five yards. Another small outcrop is said to occur 10 chains to the north-west.

Ore.—The ore, which occurs on the western side of a bed of white limestone, consists chiefly of magnetite (specific gravity, 4.86), very impure as a whole, much of it being intergrown with garnet rock. A sketch (Fig. 1) of a specimen of this is given below—it probably represents slate or impure limestone partly replaced by magnetite.

Fig. 1.

* MAGNETITE. † GARNET

IV.—KABRA.

Locality.—Kabra is a junction on the Central Railway, 11 miles south-west from Rockhampton and the Fitzroy River. Ore has been worked on portion 973, Gracemere, about a mile north-west of the station, and other small deposits are found capping a ridge running south-east through portion 146v, Gracemere. (*See* Plan 5.)

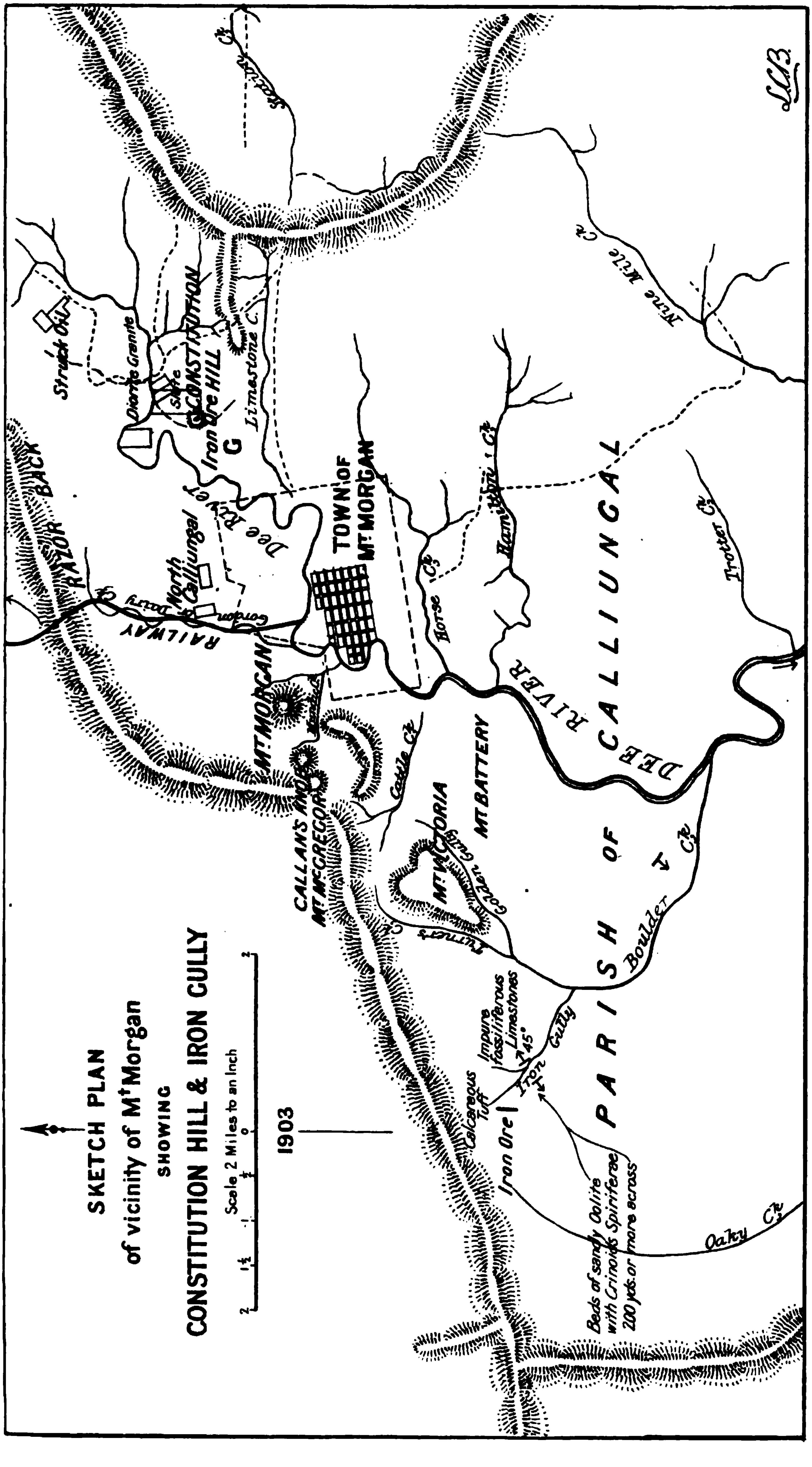
Geology.—In this locality the iron ore occurs in patches of highly-altered sedimentary rocks, the remnants of a former continuous covering over the syenitic granite, which extends from here southwards to Moonmera. Besides the iron ore, actinolite and epidote have been developed in the sedimentaries. Extensive beds of limestone lie to the north of the area being considered; they are slightly garnetiferous in most places, and the only fossils not obliterated are crinoid joints. The deposits are of the Christiania contact type, and therefore only to be expected in the calcareous sedimentaries near the intrusive granite.

Ore.—The ore consists of massive magnetite of specific gravity 4.75, the analysis of a specimen of which is (Mount Morgan):—

Water	0·17
Silica	2·85
Alumina	1·43
Iron	66·00
Manganese	—
Lime	6·61
Magnesia	trace
Phosphorus	trace
Titania	—

This shows the ore to be quite equal to the Scandinavian product. Were there any large quantity available it would be of value for mixing with the Iron Island ore.

Amount.—In the lower quarry is a patch of ore eight feet in greatest thickness, but its length is less than a chain. There are probably a number of small lenses here which could not be worked to any extent profitably. Though there is no large body of ore here much magnetite is distributed through the slates, but of course, quite unavailable.


SKETCH PLAN
of vicinity of Mt Morgan
SHOWING
CONSTITUTION HILL & IRON GULLY
Scale 2 Miles to an Inch
1903
PARISH OF CALLIUNGAL
DEE RIVER
TOWN OF Mt MORGAN
Mt MORGAN
RAILWAY
RAZOR BACK
North Calliungal
Dee River
CONSTITUTION HILL
Iron Ore HILL
G
Limestone C.
Struck Oil
Diorite Granite
Nine Mile Ck
Horse Ck
Hamilton Ck
Trotter Ck
Cattle Ck
Mt BATTERY
Mt VICTORIA
Golden Gully
Turner's Ck
CALLAN'S KNOB
Mt McGREGOR
Boulder Ck
Impure fossiliferous Limestones
45°
Calcareous Tuff
Iron Ore
Iron Gully
Beds of sandy Oolite with Crinoids Spiriferae 200 yds. or more across
Oaky Ck
LCB

The only output thus far has been 250 tons sent as flux to Mount Chalmers.

Workings.—Nicholl's Quarry on the body above referred to is ten feet in diameter and six feet deep. Besides it there are only a few trenches.

V.—MOUNT MORGAN.

(*a*) Constitution Hill.

Locality.—Constitution Hill is three miles north-east of the Mount Morgan terminus, on the eastern side of the Dee River. Between the Dee and the Rockhampton Railway Line the country presents considerable obstacles to transportation, so that the ore would have to be taken down the river to the terminus in case of it ever being worked. (*See* Plan 6.)

Extent.—Boulders and fragments of ore cover a belt with an average width of six feet from near the hilltop (where 15 feet wide) to the bottom, some 200 feet below on the south; the ore gradually gets more siliceous towards the south, there being in the lower part probably only one to three feet of pure ore, and ten feet of siliceous ore and ferruginous quartzite. To the north the ore remains pure and increases in thickness, probably to ten feet, but after two chains it either cuts out or "pinches." There may be several other parallel bodies of ore. Taking the length as five chains, the depth as one-half that, and the thickness as six feet, there will be approximately 35,600 tons of ore here.

The long grass clothing the slopes at the time of my visit rendered it difficult to determine, even approximately, the extent of the deposit; trenching would, in any case, be necessary before the exact size could be decided.

Ore.—The greater part of the ore on the south is magnetite of specific gravity 4.53, that on the north is hæmatite, the former being, as a rule, more siliceous than the latter. Samples of the less siliceous material over an average width of six feet were assayed (at Mount Morgan) for the following results:—

	North end.	South end.
Water	0·46 ...	0·30
Silica	4·00 ...	2·30
Alumina	2·02 ...	1·55
Lime	9·20 ...	2·80
Magnesia	6·14 ...	0·85
Phosphorus	trace ...	0·08
Iron	55·80 ...	62·40

The ores are thus specially pure, though that from the south end shows a rather high percentage of phosphorus—that is, for the Acid-Bessemer process, which is the more likely to be used.

Workings.—Several small potholes have been opened on the outcrop, but there are no workings worthy of the name. Owing to the large quantity of interlaminated siliceous rock the ore would be difficult to work on a large scale.

Geology.—The country rock is altered slate with a north and south strike, and the strike of the deposit is the same. The occurrence on the eastern side of the ore body of intergrown magnetite and quartz—partly replaced rock, comparable to the taconite of the American geologists—is interesting. Granite

outcrops within a quarter of a mile to the south of the outcrops, and its intrusion into the sedimentaries was most likely the cause of the formation of the ore bodies.

(*b*) Iron Gully.

Locality.—Iron Gully, one of the head branches of Boulder Creek, is six miles west-south-west of the Mount Morgan Railway terminus, in very rough country.

Extent.—There are a number of bunches of ore between the ridgetop on the south-west and the bottom of the gully 200 feet beneath. On the top of the ridge only traces of ore are to be seen, but a chain down the hill is an area ten yards in diameter, covered with fragments of ore. Half a chain below this, fragments are again in evidence, an area extending down the hill for several (five) chains, gradually widening from one-half to three chains in width, but the ore at the same time becoming gradually very impure, parts, in fact, being simply ferruginous slate. Without extensive trenching it would not be possible to determine the amount of marketable ore here, and therefore no attempt is made to calculate the quantity.

Ore.—The ore is bright and solid magnetite, with small cavities filled with powdery limonite and hæmatite. An analysis of a sample from the larger outcrop results (Mount Morgan):—

Water	...	...	0·66
Silica	...	...	8·33
Alumina	...	...	3·04
Iron	...	...	62·65
Manganese	...	...	—
Lime	...	...	2·20
Magnesia	...	...	—
Phosphorus	...	...	0·167
Titania	...	...	—

The phosphorus is thus abnormally high, and would effectually prevent the exploitation of the deposit for the supply of Acid-Bessemer furnaces. A trace of copper carbonate is occasionally to be seen, but there is not sufficient to affect the stone's value as an ore of iron. Strong stains of manganese dioxide occur in the northern part of the deposit.

No work has been done here.

Geology.—The outcrop runs north and south, the country being altered sedimentaries of Permo-Carboniferous age. Oolitic limestones occur both east and north of the ore deposit, one bed striking north-west across its northern end. West of the magnetite area is an outcrop of impure brownish limonite, with specks of hæmatite; this appears to be a partly replaced slate.

VI.—ALMA CREEK.

Locality.—Both the outcrops seen pass from 20v, Ulogie, on to the Crown land on the north-east. (*See* Plan 7.) They lie 15 miles south-south-east of the terminus of the Mount Morgan Railway. Portion 20v itself is held under grazing lease, with 20 years' tenure from 1899.

PLAN OF IRON LODES ON Portion 20v Bunerba PORT CURTIS DISTRICT

BY

LIONEL C. BALL

1903

Scale 1 Mile to an Inch

1 3/4 1/2 1/4 0 1

To Mt Morgan

Reference

G *Gabbro*

Q *Quartzites Slates &c. of undetermined age*

Plate 4 a.

Photo. L.C.B.

OUTCROP OF IRON ORE, WESTERN EXTREMITY OF OAKY LODE, ALMA CREEK.

Plate 4 b.

Photo., L.C.B.

OUTCROP OF IRON ORE, PLEASANT LODE, ALMA CREEK.

The first (Oaky lode), half a mile from the northern boundary of portion 20v, is within the watershed of Oaky Creek, a tributary of Alma Creek, which is an affluent of the Dee River. The second (Pleasant lode) is in the catchment area of Pleasant Creek, another tributary of Alma Creek, three-quarters of a mile south-east of the first.

It is most probable that there are numerous other lodes in this district. Specimens were shown me of splendid ore from the country between Alma and Centre Creeks, about three miles south-east of the above lodes. Another has been seen by Captain Richard, south of Piebald Mountain. Further, the road from Piebald to Alma passes about midway (*i.e.*, about four miles east of the Dee River) between those places, over a stretch of very ferruginous soil, in which a few fragments of jasperoid are to be found. This may be a large soft ore deposit, similar to those of Lake Superior, and is well worth prospecting by shallow pits.

The present outlet for this district is up the valley of the Dee to Mount Morgan, the terminus of a railway from Rockhampton. There would seem to be no engineering difficulties in constructing a railway to connect with that terminus.

It is to be hoped that a thorough survey may be made of this district when time permits.

Extent.—

Oaky Lode.—At the western extremity (*see* Plate 4A) the lode is six feet wide, but towards the east it quickly widens to 12 feet and runs so for five chains, when it contracts to six feet again for a chain, and then increases to ten feet, and continues so for four chains; it then pinches to two feet, but gradually increases again to the boundary fence of portion 20v, a few chains further on. Outside the fence the lode varies between two and four feet in thickness for ten chains, then pinches to a foot, but again gradually increases to an average of three feet (exceptionally ten feet), and runs so for three-quarters of a mile. The difference in level between the highest and lowest portions of the outcrop is about 300 feet, and there does not appear to be a single break in the lode.

Taking into consideration only the part of the lode within 20v, there will be (assuming the lode to continue without change in depth) 118,000 tons of ore within 100 feet of the surface.

Pleasant Lode.—This lode (*see* Plate 4B) was traced for a distance of a little over half a mile, over ridges 100 feet high, and proved to have an average width of six feet. It suddenly "pinches" just outside portion 20v. Within the portion the outcrop—a mound of fragments—varies from 10 to 15 feet across, and rises two to four feet above the general surface. The amount of ore between the surface and 100 feet depth may be calculated with the above dimensions (presuming that it persists in depth, and taking the specific gravity as 5), to be a quarter of a million tons.

A parallel lode ten chains west of the above was followed for rather less than half a mile south from the boundary fence. Its average width is less than two feet.

Ore.—The ore in all the outcrops consists of very finely granular titaniferous hæmatite and magnetite, but it is magnetic only in places, and never strongly. Through most of it there are white laths. Its specific gravity is 4.3.

The following analyses were made at Mount Morgan of representative samples collected by me:—

—	Oakey.	Pleasant (Crown Land.)	Pleasant (20v.)	Parallel (Pleasant.
Water	0.56	0·45	0·54	0·24
Silica	10·40	12·80	5·55	14·35
Alumina	1·70	9·81	12 52	12·33
Iron	56·27	55·42	55·10	48·30
Manganese	—	—	—	—
Lime	2·85	3·95	2·65	3·92
Magnesia	Not detd.	Trace	—	—
Phosphorus	0·025	0·114	Trace	Trace
Titania	Present	—	Present	—

That both the main lodes contain titania was proved, though the amount was not estimated. Titania amounting to two per cent. is usually looked upon as sufficient to condemn an ore owing to the formation of an infusible cyano-nitride in the furnace. At the same time at certain furnaces in the United States similar amounts have been successfully slagged off.

The silica, in all except the Pleasant ore, is also rather high though not excessive, owing to the presence of alumina and lime. The phosphorus in that from the Pleasant lode on Crown land is far too high for the acid process, but the others are specially low in that element.

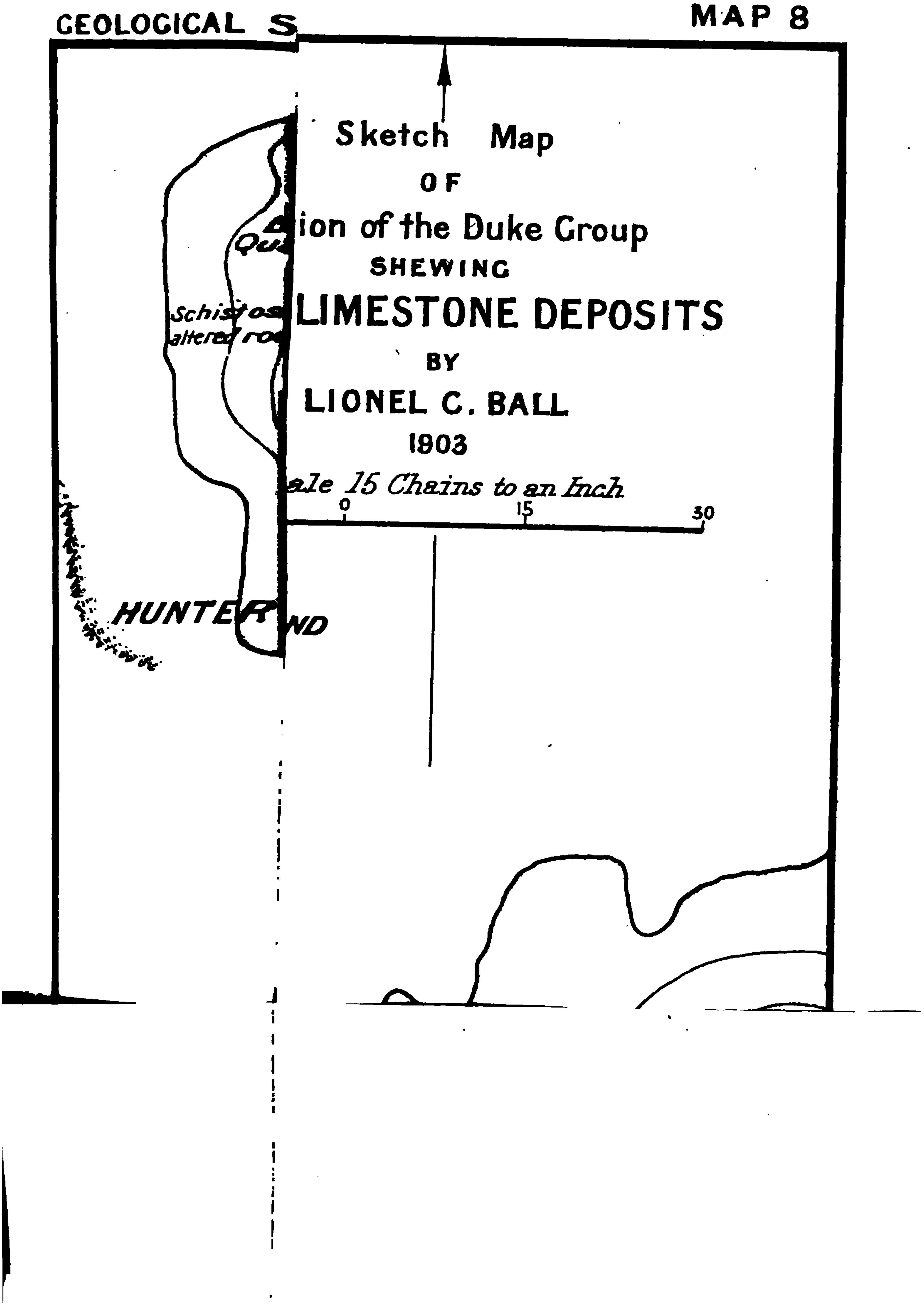
Workings.—The only workings at the present time are two or three prospecting potholes two to four feet deep, the result of leasing 160 acres on the Oaky lode in November, 1902. The surface portions might be worked by open cut methods, but owing to the comparatively small width of the ore bodies underground, mining would have to be undertaken at a slight depth.

Geology.—The lodes occur in gabbro, which in their vicinity at least is slightly schistose. Near the northern extremity of the Pleasant lode the country is less schistose, but shows orientation of the felspar, and its physical appearance is very similar to that of the ore. A section of the rock proves it to consist of plagioclase and augite, with interspaces filled with magnetite, which mineral often completely surrounds crystals of augite. Both felspar and augite are quite undecomposed, the only sign of alteration being slight stains round the magnetite.

At other places on the eastern side of the lode magnetite is greatly developed, apparently having replaced other minerals than quartz and felspar. Near the eastern portion of Oaky lode hornblende is present, and the rock there would be almost a diorite but for the magnetite filling the interspaces.

The gabbro area is about two miles in diameter (in a north and south direction), passing into metamorphic granite (altered sediments?) on the north-west, and bounded by slates on the south-west. The extent towards the east is not known. There is no reason to doubt that the gabbro is intrusive in the slates, though there was no opportunity to search for dykes in the latter.

Several fine-grained diorite dykes are to be seen in the vicinity of the Pleasant lodes, one cutting across the northern end and one running between the lodes. There is in addition a cross vein consisting chiefly of crystalline felspar, but containing in places considerable actinolite, epidote, and ilmenite. This has every appearance of an aplite, and is presumably pneumatolitic in origin. Several other outcrops of similar rock were seen at various points in the gabbro area. There is therefore a possibility of the lodes also being pneumatolitic in origin.



strongest—*i.e.*, in Lola Montes Pass—they were successfully negotiated when the Marble Island quarries were worked.

* Rep. on Geological Features of Mackay District. By R. L. Jack, 1887. Brisb. By auth.: G.S.Q.P., No. 39.

Extent.—It is about 15 chains in greatest diameter, and with the exceptions of the eastern end and a narrow diorite dyke running north and south through the centre, the whole is limestone. The height is about 100 feet. (*See* Plan 9.)

Geology.—The channel between the two islands may have been caused by trough faulting, throwing Mortar Island to the east; but even then the thin-bedded slates on the east of Mortar Island are not evident on Marble Island. Indistinct corals and crinoids were observed in the impure limestones occurring with the slates on the east, and lamellibranchs (sections), were seen in the limestone quarried on the south.

Limestone.—On the eastern side of the island is a bed, eight to ten yards wide, of limestone, "grained" white, blue, and yellow, a material specially suitable for ornamental work.

The central bed of marble is five chains across, and on the north the stone is practically without a trace of impurity; it weathers into sharp knife edges, and most of it is quite uncovered by soil or even a lichen growth. (*See* Plate 5.) This would seem to be almost fit for statuary purposes, though perhaps scarcely saccharoidal enough. It is fissured on the surface, but at a shallow depth it would be possible to obtain large blocks.

The western bed is not quite as pure as the central. The limestone on the south side of the island has a slight bluish tinge, and along cracks has been stained by percolating waters.

The stone quarried ran 98 per cent. calcium carbonate (on the authority of Mr. Campbell, who did the work). A sample taken by me from the whole island ran (Government Analyst):—

$Ca\,CO_3$	97·5
$Mg\,CO_3$	trace
$Si\,O_2$ and insoluble ...	1·88
Fe_2O_3 and Al_2O_3	0·74
	100·12

The marble thus far taken from the quarry has been bluish or creamy, but much of it, especially the mottled-blue and white, is well adapted for ornamental work, and takes a fine polish. A few specimens secured in the quarry have been polished, and are now on exhibition in the Survey Museum. A small quantity of crystalline-banded aragonite occurs, filling fissures in the quarry, and there should be a sufficient local demand for this material for ornamental work to make it worth while setting it aside in working.

Workings.—The only work done was on the southern side, where there is a quarry from which several hundred tons have been shipped. (*See* Plate 6.)

(*b*) Marble Island.

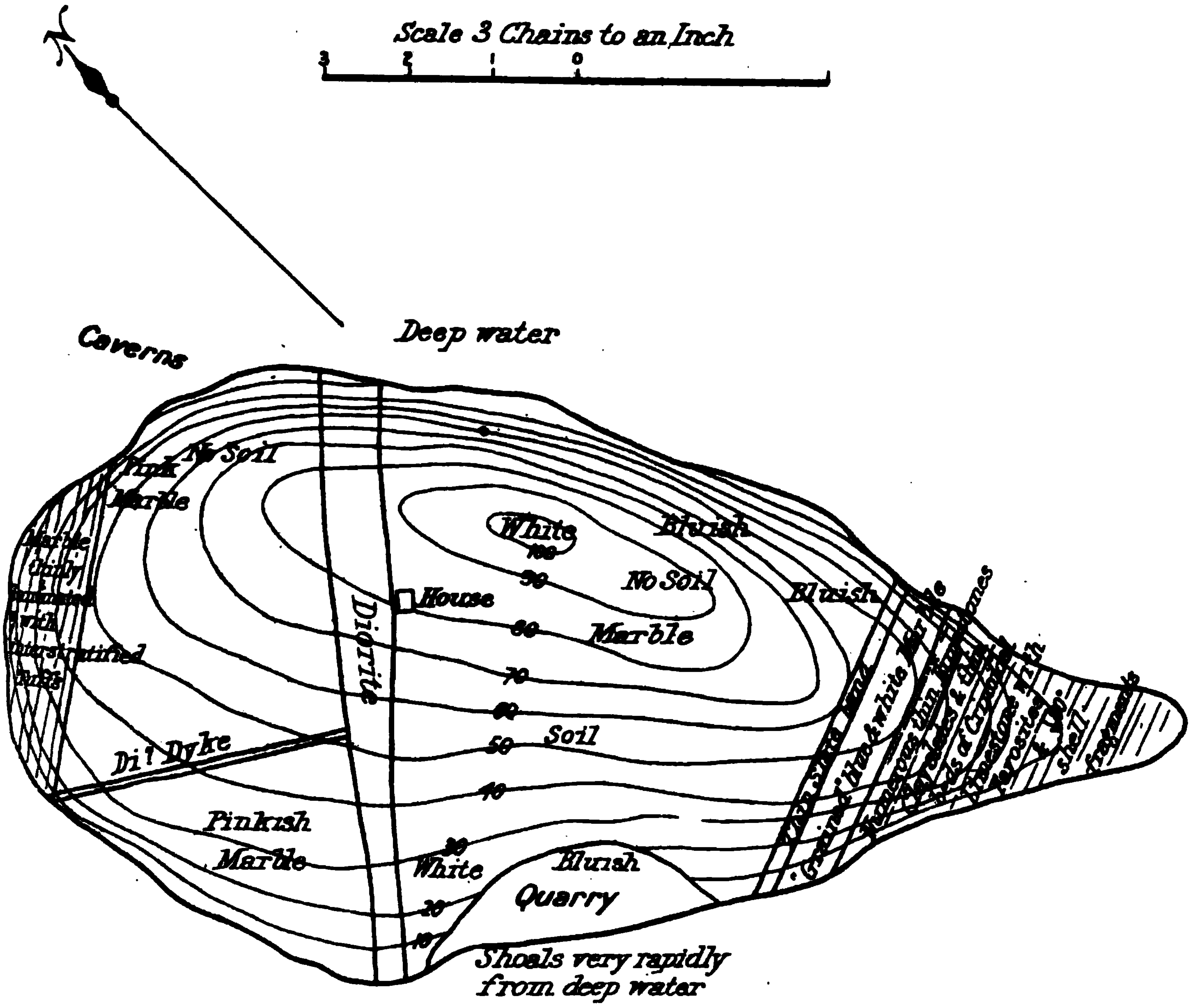
Locality.—Marble Island is the most south-easterly and the largest of the Duke Group. (*See* Map 8.)

Extent.—A number of small outcrops are to be seen in the western portion, but the main one is on the extreme north-western headland. It extends north and south for about ten chains, rising some 50 feet abruptly from deep water.

Limestone.—The limestone as a whole is not quite as pure as that on Mortar Island. It varies from pink on the north to mottled-blue towards the south, while on the extreme south is a rock resembling a conglomerate, and formed of boulders of marble. The last was originally either an impure limestone, in which segregation of the calcium carbonate has taken place, or

Sketch Plan
OF
MORTAR ISLAND
SHEWING
Extent of Marble
BY
LIONEL C. BALL
1903

Scale 3 Chains to an Inch



GEOLOGICAL SURVEY OF QUEENSLAND PLAN 10

Sketch Plan
OF
Limesione Outcrops
ON
HUNTER ISLAND
BY
LIONEL C. BALL
1903

Scale 10 Chains to an Inch

10 7½ 5 2½ 0 10

Reference

E *Devonian* *Limestone*

Plate 5 a.

Photo, L.C.B.

MORTAR ISLAND, VIEWED FROM MARBLE ISLAND.

(*Showing height of tides and Limestone Quarry.*)

Plate 5 b.

Photo., L.C.B.

MARBLE CLIFFS, NORTH-EASTERN SIDE OF MORTAR ISLAND.

(*Marble Island in the distance.*)

Plate 6 a.

Photo., L.C.B.

LIMESTONE QUARRY ON SOUTHERN SIDE OF MORTAR ISLAND.

Plate 6 b.

Photo., L.C.B.

MORTAR ISLAND AND MARBLE ISLAND QUARRY.

(*Viewed from Hunter Island.*)

Plate 7.

MARBLE, FAVOSITES POINT, HUNTER ISLAND.
(Viewed from the North at low tide.)

Photo., L. C. B.

Plate 8.

Photo, *L.C.B.*

LIMEKILN BEACH AND FAVOSITES POINT, HUNTER ISLAND.
(Viewed from Verde Antique Point at low tide.)

E

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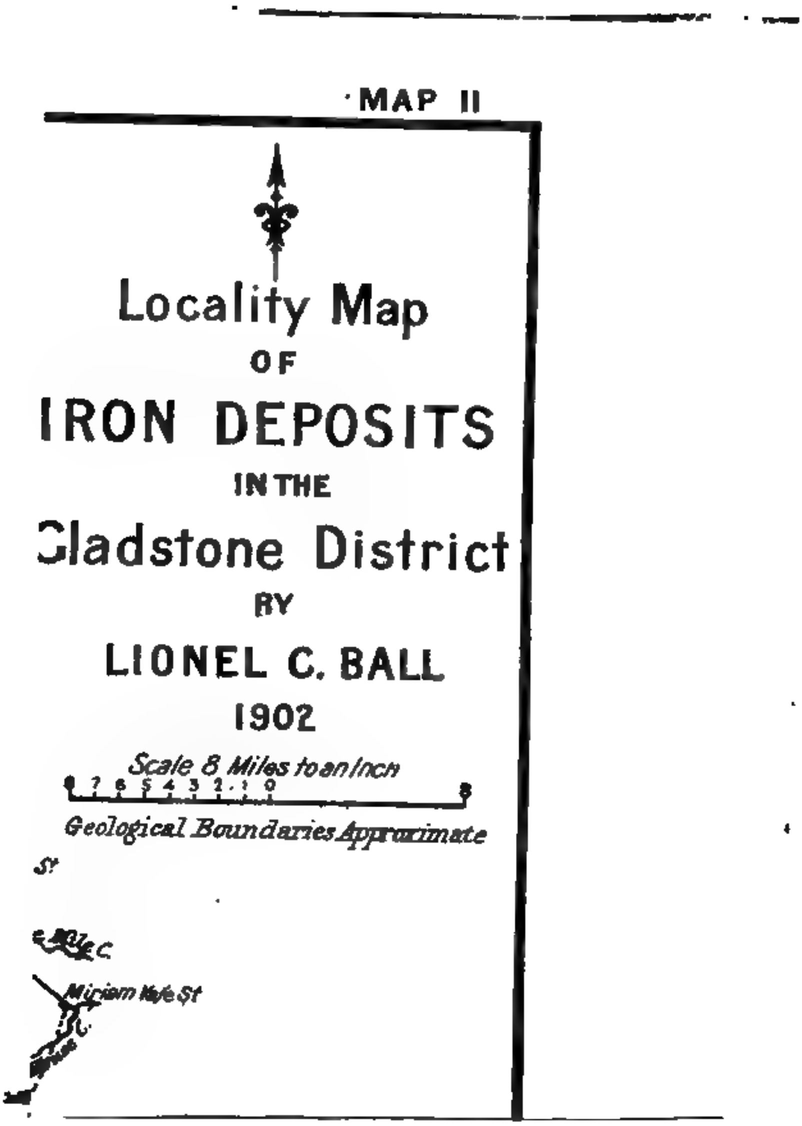
nd

an.

...n workings are at Cooroo...an. Prior to January, 1903, 123 tons ...se ore had been received at the Mount Morgan works, running ... and 70 per cent. manganese dioxide.


MAP II
Locality Map
OF
IRON DEPOSITS
IN THE
Gladstone District
BY
LIONEL C. BALL
1902
Scale 8 Miles to an Inch
8 7 6 5 4 3 2 1 0
8
Geological Boundaries Approximate
Miriam Vale St

II.—GLADSTONE DISTRICT.

A—Iron Ore Deposits.

The iron ore deposits in the Gladstone district are scattered over an area 60 miles in diameter. (*See* Locality Map 11.)

The only deposits of any considerable size are at Glassford and Many Peaks, but the outcrops at several other points, notably those on the Boyne River, are well worth testing. The places visited are described below in order from north to south.

1. TARGINIE.

Locality.—Targinie head station lies 9 miles west of Gladstone, a little over 3 miles north-north-west of the railway station of same name, and 2½ miles from the shore of Port Curtis. The head of navigable water for small boats on Boat Creek is 4 miles distant by road.

The outcrop of iron ore is half a mile south-south-east of the head station, and has been included in a lease of ten acres adjoining portion 402, Targinie (in which tho station stands), on the south-eastern corner. (*See* Plan 12.)

Extent.—Blocks of the ore up to six or seven feet in diameter cover an area of about 50 feet square, a single block being also found 150 yards south-south-west of the main outcrop. The deposit appears to be an isolated one. Its greatest thickness is ten feet on the north, from which it tapers to the south. A landslip just east of the deposit is thought by the lessee to cover a further extension to the north, but it is not likely.

Ore.—The ore is massive hæmatite and magnetite, crystalline in parts. It sometimes contains epidote and garnet. An assay of ore made for the lessee gave 94 per cent. of ferric oxide, equivalet to 65.8 per cent. metallic iron. A sample collected by me from the whole of the outcrop yields (Government Analyst):—

Iron	... ...	64·9 per cent.
Silica	... ...	5·2 „
Phosphorus	...	nil.
Sulphur ...	...	trace.

The amount of ore outcropping is less than 200 tons. There is nothing to indicate that there is a large deposit here; it is probably lenticular in form, and in that case may not contain more than 1,000 tons altogether.

Geology.—The country rock is garnetiferous epidote-bearing slate (Permo-Carboniferous?), stained in places with copper carbonates and manganese oxides. Intrusive granite is found a few hundred yards west and north of the ore deposit.

This is a contact deposit of the Christiania type, the metallic minerals having been given off from the granite, and condensed in the slates, probably on a calcareous band. The absence of limestones hereabouts is rather against any probability of considerable bodies of ore being found. Two or three shallow pot-holes and trenches have been opened beside the blocks. No prospecting for iron has been done in the district.

2. MOUNT GRIM.

Locality.—Mount Grim is in the centre of Farmer's portion 2v, Alma, 3½ miles west-south-west of Mount Alma Station, and 31 miles west of Gladstone. (*See* Map 11.) It is four miles from the Gladstone-Banana road, along which it is understood the Callide railway is to run.

Fig. 2.

Extent.—The ground was held some years ago for copper-mining, and two old fallen-in tunnels are now to be seen on an outcrop composed of blocks of magnetite up to six feet in diameter. There is nothing to show the thickness of the deposit, though it is probably less than 10 feet. West of the iron ore is garnetiferous calcite, with thin lenses of magnetite, said to carry 5 dwts. of gold per ton, patches of quartz crystals and stains of copper carbonates. (*See* Fig. 2.)

On the southern side of the ridge on which the above occurs are huge blocks of magnetite (up to six feet in diameter) over a width of 20 feet for a distance of two chains. There may be several distinct lenses.

Geology.—The country rock consists of highly altered tuff slates, &c., which, from the nature of the outcrops, it is presumed strike north and south. Granite occurs within quarter of a mile to the south.

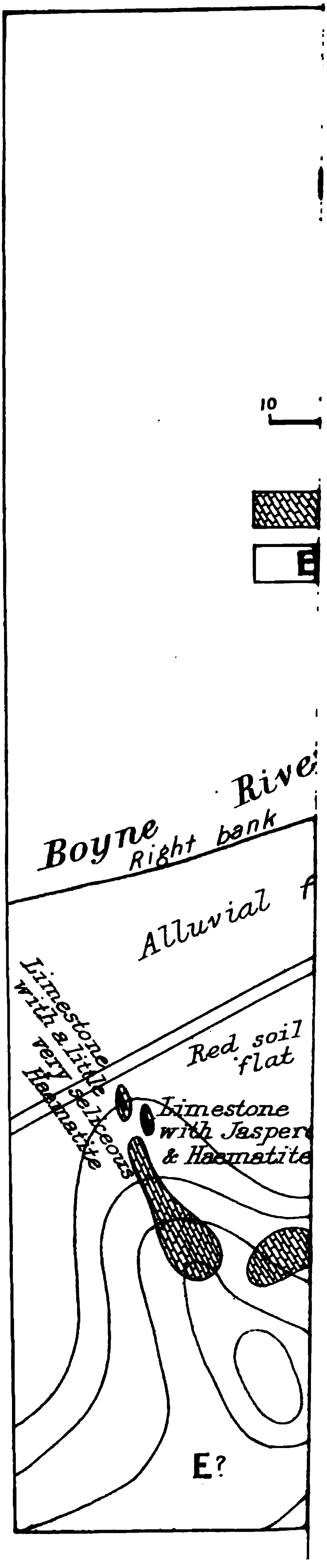
Ten chains to the west of the iron ores is a large outcrop of marble, with fragments of shells and corals (lithostrotion ?) preserved in silica. Their age is probably Permo-Carboniferous.

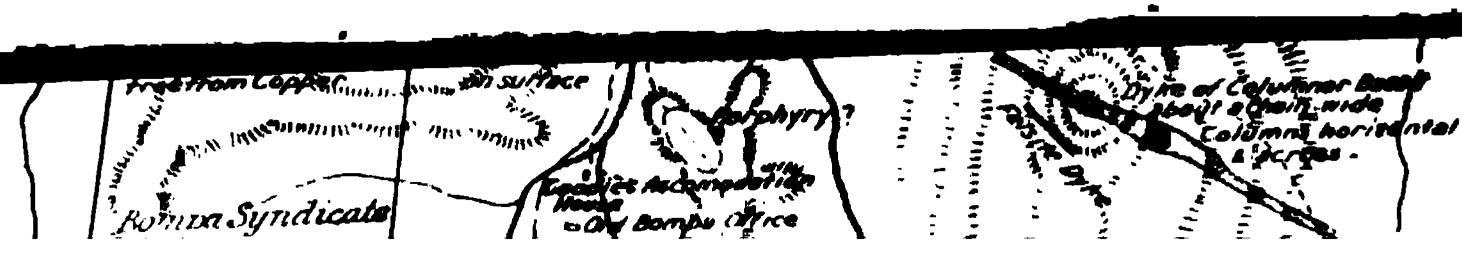
About a mile west of this magnetite boulders are very plentiful below the soil of an alluvial flat opening into Zigzag Creek, worked years ago for gold. No lode has been discovered.

Two miles south-east of Mount Alma Station are some old copper workings on garnet rock and limestone. These rocks might prove of value for fluxes.

The Callide coal leases are about 25 miles south-west from the above deposits, so that this country is worth prospecting.

GEOLOGICAL SURVE




Free from Copper
Bompa Syndicate
Porphyry ?
Dyke of Columnar Basalt about a chain wide Columns horizontal & across.
Old Bompa Office

REFERENCE.

MAP 15

in cooling has given off various metallic minerals (including oxides of iron and copper sulphides) which have been precipitated in the slates in the vicinity of limestones. Garnet rock is the chief accompanying mineral.

Extent.—The line of junction of slates and granites runs through the town, with a general north and south direction from half a mile north of it to one and a-half miles south, and on this portion most of the ore deposits are found. Outcrops of garnet rock, usually associated with ore in this district, are to be seen as far as one and a-half miles north of the town. The two main outcrops are the Blue Bag, on the Reward Claim, a quarter of a mile west of the town, and Kelly's, on No. 5 Lease, one and a-half miles south of the town. The former has a length of over a quarter of a mile, and the latter about one-eighth of a mile.

Mr. Rands, in the above report, describes the workings, which were all accessible at the time of his visit. The quotations below are from this report:—"The main deposit can be traced right through and beyond these properties (the four leases held by the Bompa Syndicate), and there are in addition other smaller ore bodies on which but little work has yet been done to test their value. The main portion of the deposit is a true lode, but in parts the country rock is also highly impregnated with copper. The country consists of quartzites, slates, and greywackes, with intrusive masses of granite. A white crystalline limestone often occurs alongside the lode." As my plan shows, there are numerous detached deposits, none of which continue through all the properties.

"Lease No. 5.—South Shaft . . . is 114 feet in depth . . . entirely in syenitic granite. At the bottom a drive was put in east for 35 feet, which for the last ten feet passed through a body of ore consisting of specular iron ore, magnetite, calcite, and copper pyrites."

"Kelly's Shaft . . . is 107 feet in depth, . . . straight down to a depth of 94 feet, when it strikes the footwall and follows the westerly underlie . . . able to get down as far as the 70-feet level, where a westerly crosscut has been driven for a distance of 25 feet, all in lode material. The ore is chiefly of magnetite, with copper pyrites disseminated through it . . . there are . . . patches of calcite, and garnetiferous rock . . . also occurs." The outcrops of garnet rock and magnetite are ten feet wide.

There is a large outcrop of garnet rock and magnetite between the South and Kelly's Shafts.

"Dowling's Shaft.—The depth . . . was 151 feet, and down to 121 feet it was entirely in the limestone, which here outcrops on western side of the lode. In the last 30 feet the ore body has an underlie of four feet, and the bottom of the shaft is entirely in ore. . . . The ore consists of magnetite and garnetiferous rock, with copper pyrites through it . . ." Probably lenticular patches of magnetite in garnet rock as well as disseminations.

"Northern Shaft, . . . 110 feet in depth, . . . entirely in limestone. A crosscut was driven west for six feet in hard garnet rock, with splashes of copper pyrites through it. A crosscut has also been driven east-south-east for 49 feet, . . . the first 42 feet in limestone, and from that point there was a formation consisting chiefly of limestone and calcite carrying numerous garnets. . . . Patches of magnetite, and a fair amount of copper pyrites." Galena and blende are both present.

Easton's Shaft was begun on garnet and hæmatite-bearing slates forming a capping on granite.

A couple of lenticular patches of hæmatite and magnetite near the centre of the northern boundary of M. L. 6, about three feet wide and ten yards long.

"Kelly's Tunnel, on Kelly's Claim, north-west alongside lode, and then west across it for 12 feet. . . . Intrusion of granite at mouth of tunnel. First six feet of ore is magnetite with copper pyrites, the remainder garnet rock." The southern tunnel is ten chains from the northern. Opened in decomposed granite just under limestone. Ore contains much magnetite, and occurs under and in the limestone. There is some fine magnetite and hæmatite on the surface just south of this.

"Reward Claim.—The Blue Bag tunnel, 27 feet in length, has been driven into the lode in a north-west direction, all in lode. . . . The gangue carries a good deal of magnetite." In the creek are up to 20 feet of garnet rock, with patches of hæmatite and magnetite and stains of carbonates of copper on the surface, giving way to copper pyrites in a few inches.

The Blue Bag Shaft is 100 feet deep, with a steep underlie to west for 50 feet, and then vertical. In a rich bunch of ore lying on decomposed porphyritic granite and adjacent to the Blue Bag garnet rock. A few chains to the north is another shaft, 30 feet deep, with a drive for 30 yards to the south-west at the bottom, passing through cupriferous garnet rock. In the face is massive hæmatite.

"The (Blue Bag) lode in Glassford Creek consists on its east side of quartzite and garnet rock, with copper pyrites. Next to this there is five feet in width of magnetite, in which are large cavities filled with calcite. The magnetite contains copper pyrites throughout it. Then there is four feet of garnet rock with copper carbonates. The lode is certainly 25 feet wide." Ten feet width of ore rises 15 feet above the ground on the side of the creek, and consists in great part of magnetite, chiefly as bunches, with copper pyrites in garnet rock.

"Big Blow.—At northern boundary of the Reward Claim is the North Tunnel, driven about 100 feet in a westerly direction, through quarzites and hard garnet rock. At the face is hard garnet rock, with copper pyrites and large patches of magnetite."

The tunnel is driven under a very large copper-stained garnet blow. The garnet rock here does not look promising either for iron or copper.

Amount.—Taking the amount of magnetite in the Glassford ore as one-fifth of the whole, the total amount of ore within 200 feet of the surface on the leases now held will not exceed half a million tons.

Future.—The only possibility of the iron ore being worked is in connection with the copper and gold. Magnetic concentration would leave the copper and gold ore in an ideal condition for smelting, the magnetite in a pure state being obtained as a by-product.

It is proposed to construct a railway line either to Miriam Vale, *viâ* Many Peaks and Mount Jacob, a distance of 33¼ miles; or to Gladstone, following the mail road down the Boyne River, a distance of 80 miles.

8. CANIA.

(*See* Map 11.)

Township.

Locality.—Cania is 58 miles south-south-west of Gladstone, and the same distance north-west of Mount Perry. Miriam Vale, the nearest railway station, is 42 miles distant.

Extent.—Half a mile east of and above the township is a small deposit, about a chain in diameter, of cellular, rather siliceous, limonite. The iron ore probably replaces Permo-Carboniferous limestone, an outcrop of which occurs on the west, and it may pass into carbonate at a depth. This body alone is of no value, but it points to the possibility of there being others in the locality.

SPRING CREEK.

Locality.—The old Spring Creek Gold Diggings are ten miles north-east of Cania.

Extent.—There are several small outcrops of iron ore in this locality, the largest crossing the Cania-Monal road, about quarter of a mile west of the workings. This is about two feet wide, and in places consists of pure hæmatite with garnet rock, but as a whole would not be pure enough even if large enough to be worked. The country rock here is Devonian (?) slate and tuff, dipping 70 degrees to south-west.

There is at present no practicable outlet for ore from here, the Burnett Range being to the west—*i.e.*, towards the Callide Coal Field—and Dawes' Range to the east, towards Mount Perry. To within 25 miles of Mount Perry there is a gentle down-grade, but the country then becomes broken.

9. CABBAGE-TREE.

Locality.—Cabbage-tree lies 54 miles south of Gladstone, on the southern flanks of Dawes' Range. It is 40 miles north-north-west of Mount Perry. (*See* Map 11.) A few years ago several leases were taken up for copper-mining, but now the place is practically deserted.

Outcrops.—Impure hæmatite and limonite blows occur on Monument Hill, near some old trenches, and there are numerous iron-stained outcrops.

Blocks of hæmatite can be seen in the creek on the western side of Apple-tree Lease.

The largest hæmatite outcrop seen here is on the head branch of a small creek about half a mile south of the hotel. It strikes north-west, its greatest width is ten feet, and it runs for about a chain. The ore consists of hæmatite and limonite, and is nearly free from quartz.

B—Limestones.

1. CALLIOPE RIVER.

(*a*) CALLIOPE CROSSING.

In the bed of the Calliope River, between portion 1, West Stowe, and portion 66, East Stowe, a quarter of a mile below the crossing on the Gladstone-Rockhampton road, are several exposures of limestone, all within a radius of ten chains. (*See* Map 20.)

The main, most northern, outcrop is about 50 feet wide, 25 feet high and five chains long. It consists mostly of very pure light-grey marble, but much of it is beautifully coloured. It contains, as a whole, one per cent. of visible impurity (veinlets and coatings of iron oxides and clay). The limestone continues to the north, but is covered by the alluvial soil on the bank of the river. A nine-feet dyke of porphyrite (?) runs through the limestone, the three feet in centre being coarsely porphyritic, while the outsides are very fine-grained.

A few chains south of the above are several other outcrops, up to four chains in length. That near the centre of the river is 20 feet wide, and consists of a reddish limestone, traversed by very ferruginous veins, which should be of great value for building and monumental purposes.

Within half a chain of this, on the west, is another outcrop 20 feet wide, and the Marble Island in the river, six chains to the south, may be a continuation of this bed. The greater part is pure bluish stone, with cross-veins of white calcite, the couple of feet on each side being very ferruginous. The rock has the structure of a conglomerate but consists entirely of limestone. It tapers out to the north.

West of this, near the bank of the river, is a north and south zone, containing overlapping interbedded lenticular masses of limestone. This would probably be of use for a building-stone, but is too impure for lime-making. The limestone has the appearance both of replacing the slates (on the sides) and of having segregated from them, in which case the clayey impurities remaining have encrusted the lumps of limestone. The rock looks like a re-cemented breccia or a conglomerate. In large masses the limestone is very pure, containing only a few fragments of reddish slate, amounting to perhaps one per cent. of the whole. That the limestone is in part original is proved by the indistinct crinoids, corals (cyathophylloids?), seen in parts of it. West of the limestone is a thick bed of limestone and slate conglomerate, the fragments being held together by a greyish cement.

The quality of the limestone in this locality is not as good as could be wished, the amount of iron present preventing its use in sugar refineries. The whole of the rock is perfectly suitable for building-stone, and most of it is pure enough for ordinary lime-making.

There appears to be a bar of rocks across the river, a quarter of a mile below the limestones, but it is affirmed locally that small boats can reach the stone at high tide. A considerable quantity was, in fact, shipped from here to Bundaberg some twenty years ago. The Calliope landing is only a mile below.

(*b*) Portions 77 and 78, Auckland (Wanmer's).

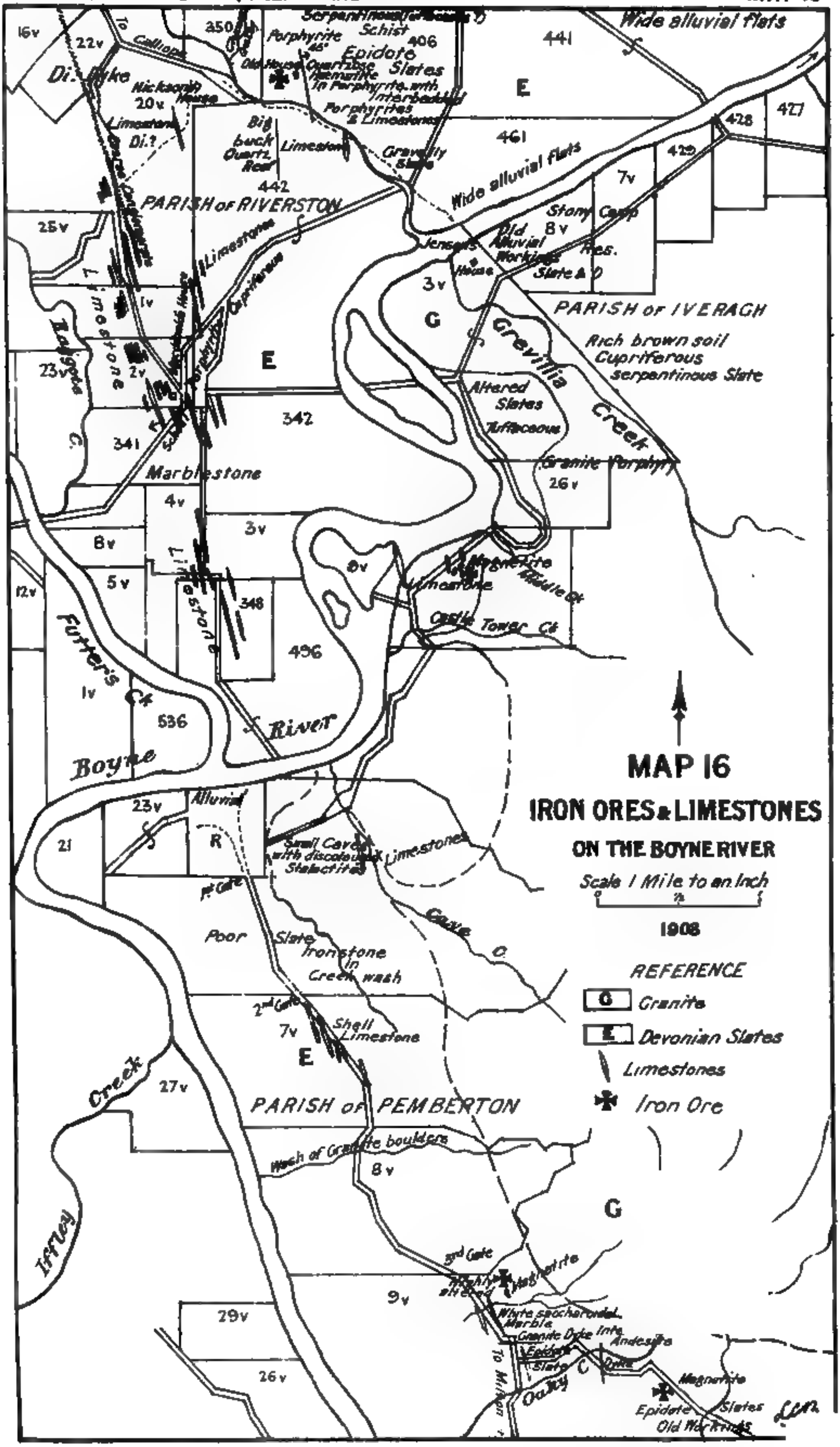
The deposits lie at the eastern ends of the portions, one mile from the Calliope River and eight miles south-west of Gladstone. (*See* Map 20.)

A small quarry has been opened on the deposit, which can be traced for several chains in a northerly direction, with a width of about two chains. The rock on the surface is much fractured, and the interspaces have been filled with red clay, staining the limestone and rendering it unfit for sugar refining. In the quarry the north-eastern part is rather impure, and when not actually impure internally it is much cracked, and the cracks are stained with ferruginous clay. The south-eastern portion is very pure.

Indistinct corals and crinoids are to be seen at times, proving that the limestone has been organically formed.

The position is a good one for exploitation, the road to the Calliope River having a gentle downward slope all the way. At the landing small 20-ton schooners are loaded, and if necessary the stone is transhipped at Gladstone.

Five hundred tons of limestone have been shipped from here to Bundaberg for the sugar refineries.


MAP 16
IRON ORES & LIMESTONES
ON THE BOYNE RIVER
Scale 1 Mile to an Inch
1908
REFERENCE
G Granite
E Devonian Slates
Limestones
Iron Ore
Wide alluvial flats
PARISH of RIVERSTON
PARISH of IVERAGH
PARISH of PEMBERTON
Rich brown soil
Cupriferous
serpentinous Slate
Grevillia Creek
Altered Slates
Tuffaceous
Granite Porphyry
Boyne River
Futter's Ck
Marblestone
Limestone
Stony Camp
Old Alluvial Workings
Jensen's House
Castle Tower Ck
Magnetite
Middle Ck
Small Cave with discoloured Stalactites
Limestones
Cave C
Poor Slate
Ironstone in Creek wash
Shell Limestone
Wash of Granite boulders
Whyte saccharoidal Marble
Granite Dyke
Andesite
Epidote Slates
Old Workings
Oaky C
To Milton
Iffley Creek
Alluvial
Big buck Quartz Reef
Porphyrite
Schist
Epidote Slates
Old House
Quartzose Hematite in Porphyrite with interbedded Porphyrites & Limestones
Gravelly Slate
Nickson's House
Di. Dyke
To Calliope
Kalgoola
Cupriferous

2. CALLIOPE—MARBLESTONE—BOYNE.

From the 10-chain road two miles north of Calliope to the Eastern Boyne (15 miles) is a north-north-west belt of country one to two miles wide, in which very numerous outcrops of limestone are found. In the vicinity of the township of Calliope the outcrops are few and far between, but toward the head waters of Leixlip Creek they are more plentiful; the greatest development in the district is on the southern side of the Boyne Range, between Raggote Creek and the Boyne River, and owing to the size, persistence, and number of the beds, the locality has received the name of Marblestone. Beyond Marblestone, to the south, isolated outcrops occur at intervals almost to the head of the Boyne River. (*See* Locality Maps 11 and 19.)

(*a*) Calliope.

(i.) On Marck's, portions 338 and 176, East Stowe, ten miles south of Gladstone, are three belts of non-fossiliferous limestone, one quarter of a mile in length and half a chain wide, striking about west-north-west. The limestone is very pure, and in fact the best seen in the district. Cartage to the landing on the Calliope River, a little over four miles distant, should not cost more than 4s. per ton. The distance from the outcrops to Annandale Station, on the Maryborough-Gladstone Railway, is seven miles by way of the 10-chain road, which presents no difficulties to teams. (*See* Map 24.)

(ii.) On the head of Bedford Creek, 2½ miles south-east of Calliope, are several outcrops of limestone.

(iii.) The first outcrop on Leixlip Creek is on the western side of the Marblestone road, two miles south-south-east of Calliope. Then numerous other outcrops occur on the heads of Ten-men Gully and Brennan's Flat.

(*b*) Marblestone.

From Hickman's, portion 20, on the north, to portion 348, there is limestone practically all the way. The outcrops strike about north-north-west; as a rule they do not exceed a quarter of a mile in length, and owing to the development of separate lenses side by side the width is often as great as the length. (*See* Map 16.)

The greatest development is on portion 2v, Riverstone, beside the Calliope-Milton road, near the junction with a surveyed road, *viâ* Riverstone, to Annandale Railway Station (which is ten miles distant).

On portion 2v, the beds strike north 10 degrees west, and dip 70 degrees to east.

There is one large outcrop on the north and one on the south of the portion, but these are in all probability connected.

The limestones are, as a rule, pale blue or neutral tinted, mostly very pure, and therefore well adapted for lime-making. On portion 2v, the beds are highly fossiliferous, containing stromatopora (most abundant, forming whole beds up to 10 feet thick, in which the separate coral masses are often 18 inches or more across), cœnites, favosites, lithostrotion, cyathophylloids, cystiphyllum, &c., with a few shells. One belt in the limestone has the fossils replaced and preserved by silica.

There is also a belt of breccia, consisting of angular fragments of limestone in a red ferruginous cement. The bed is only a few feet in width, but outcrops for several chains. The rock takes a fine polish, and will hold its own with any of the imported breccia marbles.

(c) Boyne River.

Other extensive beds of limestone occur on portions 20v, 25v, 1v, 442, 341, 342, 4v, and 348, Riverstone—in fact, all along the Marblestone road. (*See* Map 16.) Very little of the stone is at all impure, most of it being light-blue in colour and granular in texture.

South of the Boyne, the first outcrops are on portion 22v, Pemberton, within quarter of a mile of the river.

There are other outcrops on Cave Creek, in portion 6v, Pemberton, about half a mile from the river.

In portion 7v, Pemberton, there are several outcrops of impure shell limestone, which would probably give good results as a hydraulic lime.

In portion 9v, Pemberton, there are several outcrops, one of which, on the road, is pure white, and saccharoidal in texture. The outcrop here is several chains in length. The limestone has been altered by the intrusion of the Many Peaks granite mass, which lies only half a mile to the east. This is quite sufficient indication to warrant extensive prospecting, but the demand gives no encouragement. The total Italian exports in 1902, a little over 327,000 tons, was valued at only 32s. a ton.

A probable continuation of the Marblestone belt is seen between Littlemere and Glassford Creek, at the head of the Boyne.

A 10-foot bed of pure white limestone lies two miles north of the Many Peaks Mine. It strikes north and south, and contains a few indistinct fossils.

A large outcrop lies about half a mile south of portion 10v, Milton. The bed is probably two chains in width, and can be followed for over a mile. The limestone is somewhat altered, but contains recognisable favosites, heliolites, cœnites, crinoids, bivalves, branching stenopora, and forams (?).

3. CATFISH.

A number of limstone outcrops occur on the Gladstone-Banana road, from the Catfish Hotel (which is 21 miles south-west of Gladstone) to the Wycheproof turn-off, three miles to the north-east. (*See* Map 17.) The beds have a general strike a little west of north, and the zone may possibly be a western extension of that at Calliope. The beds are up to one and a-half chains in width and half a mile in length, and the greater part is rather impure, though the stone in some of the beds (blue and grey) is sufficiently pure for lime-making. Some of the other beds are beautifully coloured. Fossil stromatopora, favosites, &c., are not very well preserved, though plentiful. Age—Devonian.

Other outcrops occur on the Calliope River, in portion 1v, West Stowe, about 20 chains above Ferguson's Crossing. The stone is a beautiful white marble, and would probably be of use for ornamental purposes.

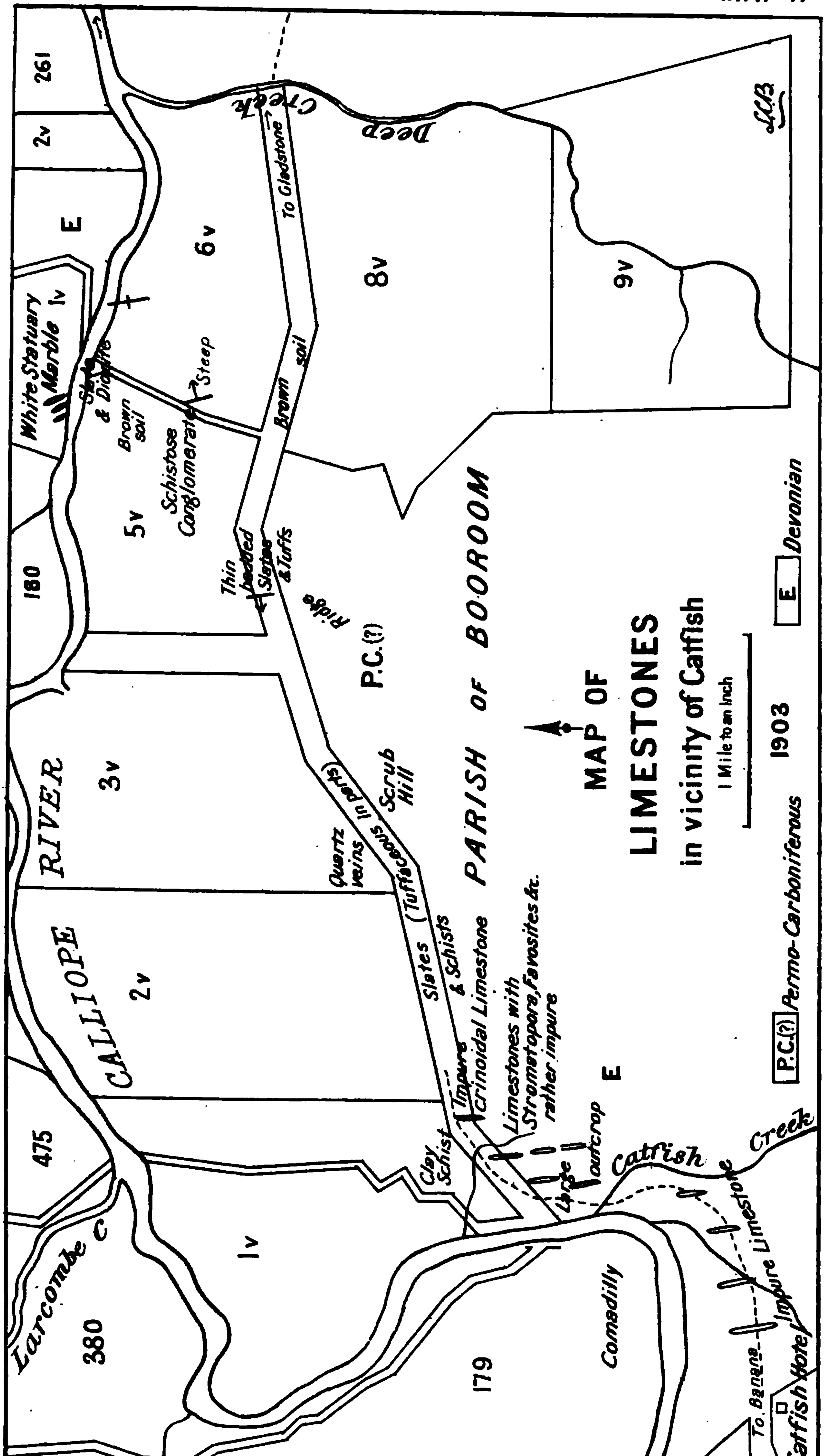
Several outcrops of marble occur on Mount Grim, on portion 2v, Alma, 31 miles west of Gladstone. The limestones have been highly altered, but still contain traces of corals and shells, pointing to their age being Permo-Carboniferous.

4. DIGLUM.

On Diglum and Booreeco Creeks, 30 miles south by west of Gladstone, are several north and south belts of limestone at intervals of half a mile, over an area four miles in diameter. Some of the limestones can be traced for over a mile. (*See* Map 18.)

Some of the limestone is very saccharoidal, but even then contains dendroid syringopora, beautifully preserved in silica.

GEOLOGICAL SURVEY OF QUEENSLAND MAP 17



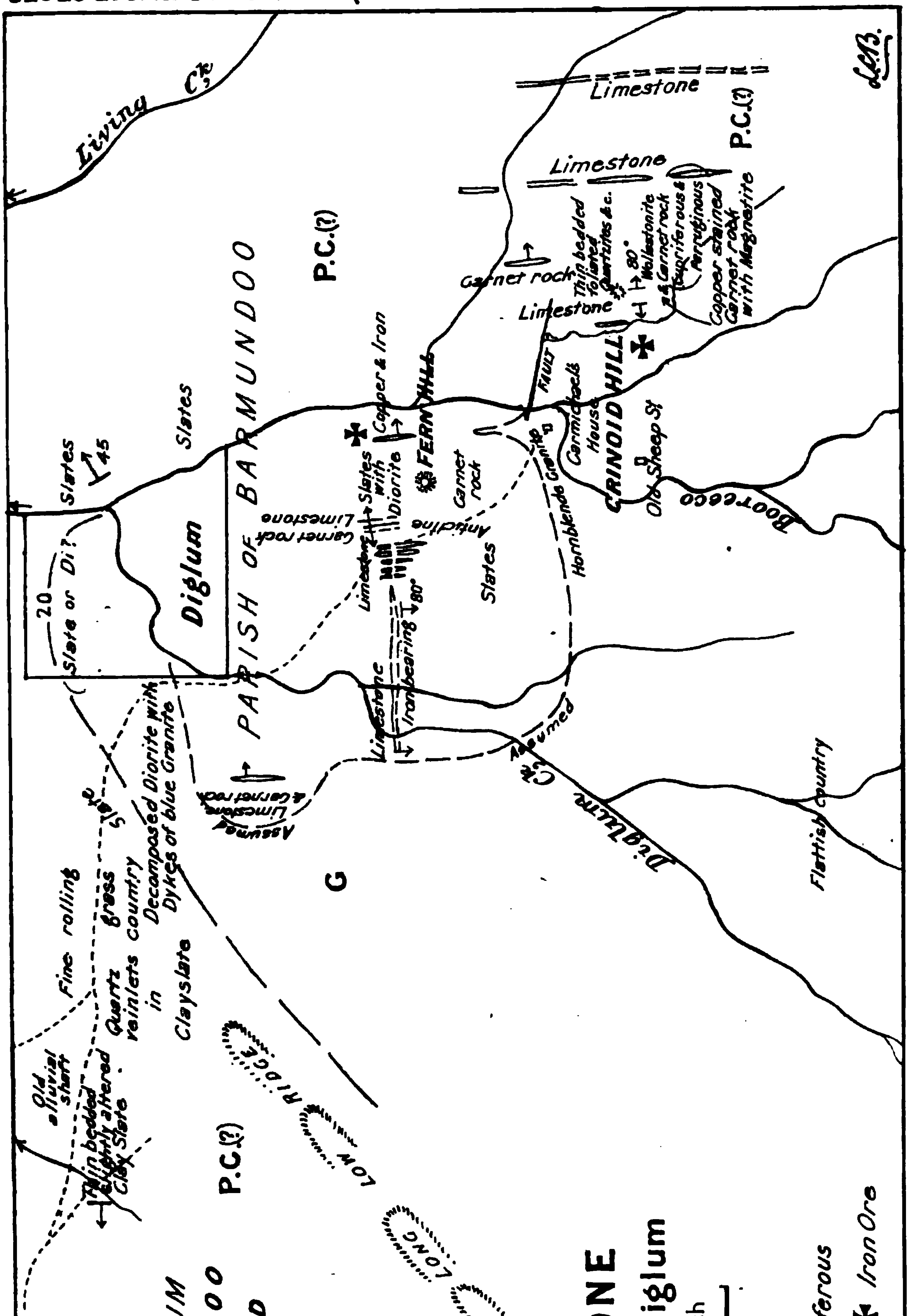

MAP 18
LIMESTONE
in vicinity of Diglum
1 Mile to an Inch
1903
P.C.(?) Permo. Carboniferous
G Granite
Iron Ore
PART OF
PARISH of DIGLUM
BARMUNDOO
GOLDFIELD
PARISH OF BARMUNDOO
Diglum
Living Ck
Diglum Ck
Boorooco
Limestone
P.C.(?)
G
Slates
Slate or Di?
FERN HILL
CRINOID HILL
Garnet rock
Copper & Iron
Slates with Diorite
Anticline
Garnet rock Limestone
Ironbearing
Hornblende Granite
Carmichael's House
Old Sheep St
Fault
Thin bedded foliated quartzites &c.
Wollastonite & Garnet rock
Copper stained Garnet rock with Magnetite
Assumed
Limestone & Garnet rock
Decomposed Diorite with Dykes of blue Granite
Fine rolling grass country
Quartz veinlets in Clayslate
Old alluvial shaft
Thin bedded slightly altered Clay Slate
LOW RIDGE
LONG
Flattish country
Altered Conglomerate
Walls Hut
Slate
Futters
LCB.

Plate 9.

Coralline Limestone, Kroombit

Photo., L.C.B.

Some of the rocks here have been highly altered by the intrusion of a basic granite, which seems to extend to the head of Diglum Creek on the south. Wollastonite and garnet are found at several places near the junction.

The remoteness of the locality will prevent anything being done with these deposits for many years to come. They are here simply recorded, though already mentioned in a report of Mr. Dunstan's.*

5. KROOMBIT.

(*See* Map 11.)

Immense beds of fossiliferous limestone occur on Kroombit Creek, five miles above Kroombit Head Station. Exposure up to a quarter of a mile wide occur, and some of the cliffs on the creek are 50 feet in height. They are essentially coral beds, the lime being very pure.

The fossils include heliolites, stromatopora, and cœnites, with occasional shells and crinoids. The beds are believed to be of Devonian age, and within a mile to the west are tuff shales and sandstones overlying them unconformably, and containing zaphrentis, &c., and believed to be Permo-Carboniferous.

Other limestones occur at the Five-mile Copper Mines, five miles south-east of Kroombit, but have there been highly altered, and could only be of use for smelting.

6. GLASSFORD.

(*See* Maps 11 and 15.)

Several outcrops of limestone occur in the vicinity of Glassford Creek township, both north and south. It is in and near these limestones that the Glassford copper and iron ore occurs, and the limestones have been highly altered by the intrusion of granite. The limestones containing garnet rock are eminently adapted for smelting, but most of it is probably too siliceous for lime-making.

At Sandberger, some four miles south of Glassford, and at Mount Hector, some six miles north-west, similar highly altered limestones are found.

7. CANIA.

Oolitic limestones occur on both sides of Dawes' Range, on the Kroombit-Cania road, as well as at several places in the vicinity of Cania township, on both Four-mile and Three-Moon Creeks. The stone is light-blue in colour, and of a very good quality. Permo-Carboniferous fossils, martinia (?), pteronites (?), spirifera, and zaphrentis are occasionally found in them.

One outcrop, three miles west of Cania, is 50 feet thick and several chains in length.

Other beds are found on Spring Creek, five miles north-east of Cania, in very inaccessible country.

8. CANINDAH.

(*See* Map 11.)

Three large beds of limestones are crossed by the Canindah-Cania mail track in portion 7v, North Canindah, between Kalonga and Splinter Creeks. The stone on Kalonga Creek is pure, but most of that between Branch and Splinter Creeks is very impure, and suitable for nothing with the possible exception of hydraulic lime-making, and the inaccessibility of the locality will prevent its being worked for that purpose.

* G.S.Q. Publication, No. 162.

C—Manganese Ore Deposits.

1. AREA, TOPOGRAPHY, AND TRANSPORT.

The area within which manganese ore has been found in the Gladstone district is roughly 15 miles in greatest length and 12 miles in greatest width—viz., from Targinie on the north-west, to Calliope on the south, and Quoin Island on the east. (*See* Locality Map 19.)

Between Gladstone, on the shores of Port Curtis, and Dawes' Range, 45 miles to the west-south-west, there are really no mountains, and most of the country within the manganese area is less than 100 feet above sea-level, the highest hills being not much over 500 feet in altitude. The rocks near the manganese deposits being generally indurated in character, have proved very resistent to atmospheric denudation, and consequently occur on the higher ridges and hills, such as One-tree Hill, Biondello, Mount Beecher, and Mount Miller. The soil over the greater part of the area is poor, the ridges being stony, the flats sandy. The ironbark on the ridges is the chief timber.

The influence of the strike of the strata is seen in the general northerly course of the Calliope River, of its tributary Saltwater Creek, and of Policeman or Auckland Creek, in the northerly pointing headlands about Gladstone, and in the northerly trend of most of the islands in Port Curtis.

Port Curtis has an average width of four miles, and from the mouth of the Calliope River to Gatcombe Head is ten miles, offering anchorage for a fleet, even though a large part is shoal.

Auckland Creek, beside which Gladstone lies, is really an inlet into the upper part of which Policeman Creek empties. It is navigable owing to dredging for a few hundred yards from the end of Auckland Point—*i.e.*, to the wharves in the town, where boats of 1,000 tons burden can berth.

The Calliope is navigable for 12 miles above its mouth—*i.e.*, up to the bar at the entrance of Saltwater Creek—for boats of 300 tons, and beyond the bar up to the Mount Miller landing for boats of 100 tons, while 50-ton boats have been up to the marble bar at the Carrara Crossing. The present outlet for manganese ore is by the Calliope River, 20 to 50-ton schooners taking it up the Narrows to Rockhampton.

The Gladstone-Rockhampton Railway has now been opened, so that it is possible to rail to Rockhampton, Gladstone, or Brisbane.

2. GEOLOGY.

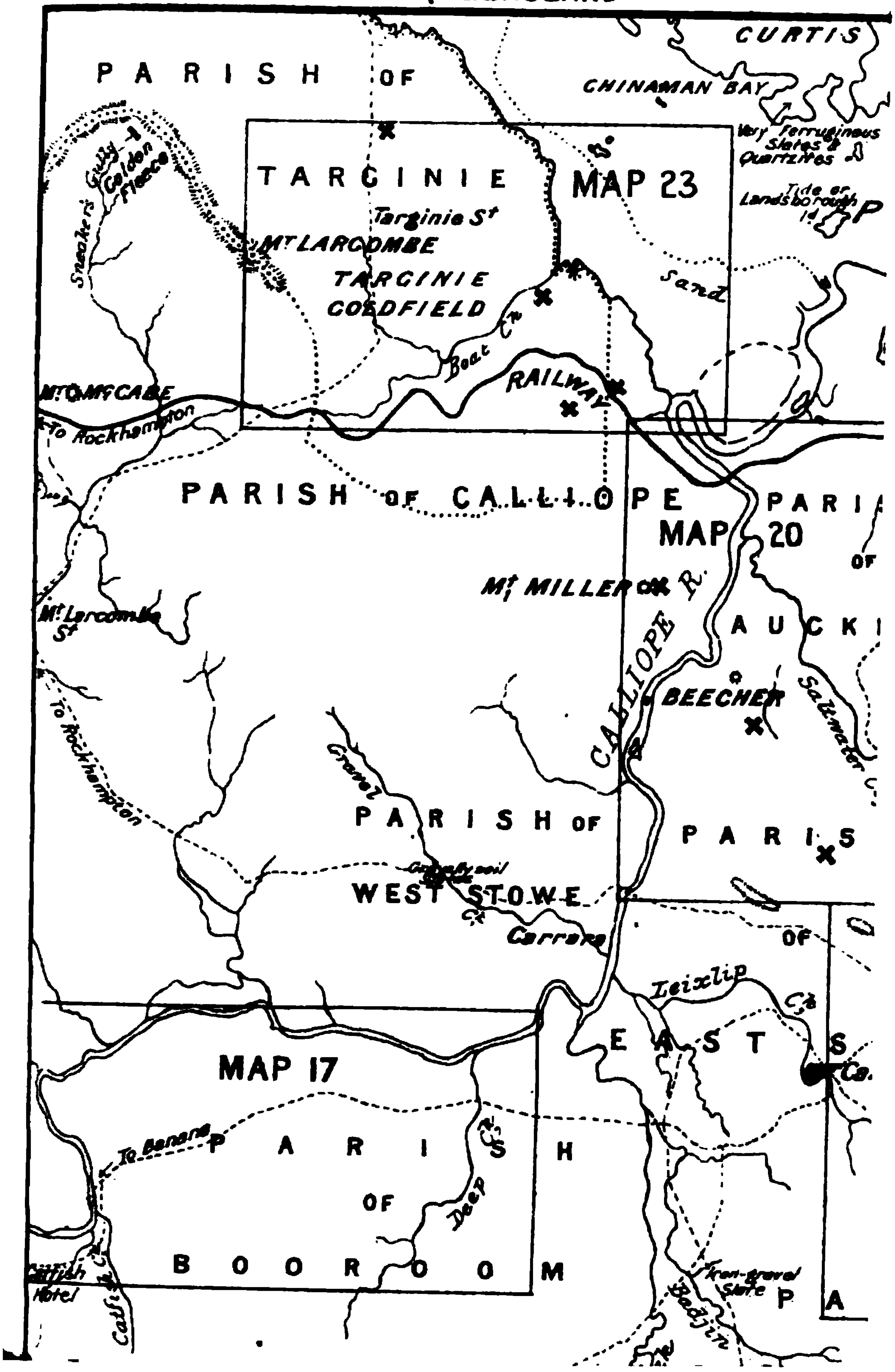
Of the Country as a Whole.

The manganese area consists, as a whole, of massive slates, quartzites, jasperoids, and sandy clay schists, variously intersected by dykes of trachyte, syenite, and diorite. The only other formations are the river and estuarine alluvials. Not a single fossil has been found within the area, but a little further west (at the Calliope Crossing) and south (at Marblestone), are limestones whose fossils prove the beds to be of Devonian age. The beds were shown as Gympie (Permo-Carboniferous) on the last large State geological map, but have been altered to Devonian on the later small map. The general strike of the strata is between north-north-west and north; the dip generally, where discernible, is to the east, and varies from 60 to almost 90 degrees.

Of the dyke rocks sanidine trachyte is found on Picnic Island, and on the Calliope road, just west of Gladstone.* Diorite and syenite outcrops are

* Rep. on Goldfields in Port Curtis Distr., &c. By William H. R. G.S.Q.P., No. 21. Brisb.: By Authority, 1885.

GEOLOGICAL SURVEY OF QUEENSLAND



The mines will be described in the order of their importance, judging from the amount of work done and the ore raised hitherto. It will be seen that only one, the Mount Miller, is now actually producing ore, though the Auckland Hill Mine should not be lying idle.

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numerous between Annandale on the south and Targinie on the north, but most abundant between Skyring's Siding and the Gladstone reservoir. These dykes and the manganese deposits are in no way connected, there being no manganese where the dykes are most abundant, and as a rule no dykes in the vicinity of the ore deposits. Auckland Hill is an exception in that dykes occur at the base of the hill, though not adjacent to the deposits.

The typical surface country for manganese is hard, flinty, red or brown, sometimes quartz-veined jasperoid—clay slate, indurated and coloured owing to partial or complete replacement by silica and oxides of iron. These indurated rocks pass at from 20 to 50 feet depth into soft brown or yellow clay slate (or schist) or bluish quartzite.

Micro-sections show the jasperoid in the last stages to consist chiefly of minute prickly spheres of hæmatite in a base of secondary silica. Secondary silica also occurs in veins. Other specimens show slate partly replaced where much fractured. Search for radiolaria has been quite unsuccessful, everything pointing to the jasperoid being of secondary origin.

Of the Ore Deposits.

The deposits are lenticular, lying, with very few exceptions, with their longer axes parallel to the bedding of the slates. As a rule the outcrop is small, and the work thus far points to the depth of the lenses being no greater than their greatest length. There will probably be a number of overlapping lenses, extending to some depth, and only prospecting can determine whether these occur near enough to one another to be profitably worked. A fact noticed by prospectors is that the deposits in this district always pitch to the north, indicating a connection with cross fissures, which at Mount Miller separate rich and poor ore.

There cannot be the slightest doubt as to the secondary nature of most of the ore. That partly filling cavities in the Mount Miller deposit has a stalactitic and concentric structure, and in all the deposits specimens of slate and jasperoid can be obtained showing veins of manganese ore. Some of the ore has the structure of slate, which it appears to have metasomatically replaced, and specimens of slate partly changed into manganese ore are, in fact, not uncommon. It seems most likely that the manganese existed originally both as disseminations and small beds in the slates, which in all probability are deep-sea deposits; and further, that after the tilting of the slates the disseminated manganese ore was concentrated about the original beds, or possibly on lines of fracture, by carbonic acid solutions.

The ore deposits may be considered to form belts running about north and south with a tendency towards north-north-west—*i.e.*, parallel to the strike of the country. Gladstone is on one of these belts, extending northwards through the islands in Port Curtis, and southwards (through Round Mountain or One-tree Hill) to Biondello. The second belt crosses the Calliope River, six miles west of Gladstone, and extends from the railway line through Mount Miller and Mount Beecher south almost to Calliope.

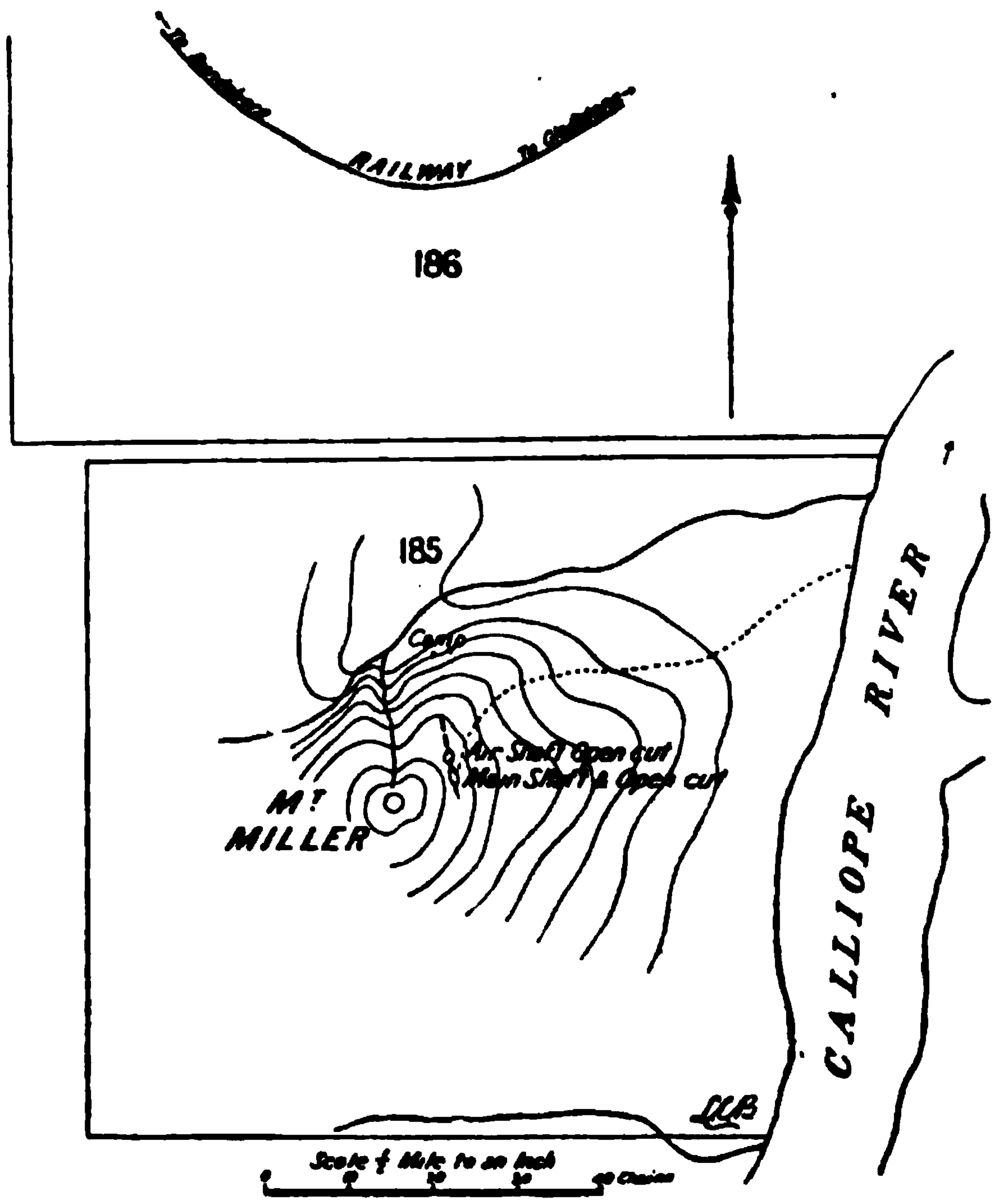
3. MINES.

The mines will be described in the order of their importance, judging from the amount of work done and the ore raised hitherto. It will be seen that only one, the Mount Miller, is now actually producing ore, though the Auckland Hill Mine should not be lying idle.

I.—MOUNT MILLER.

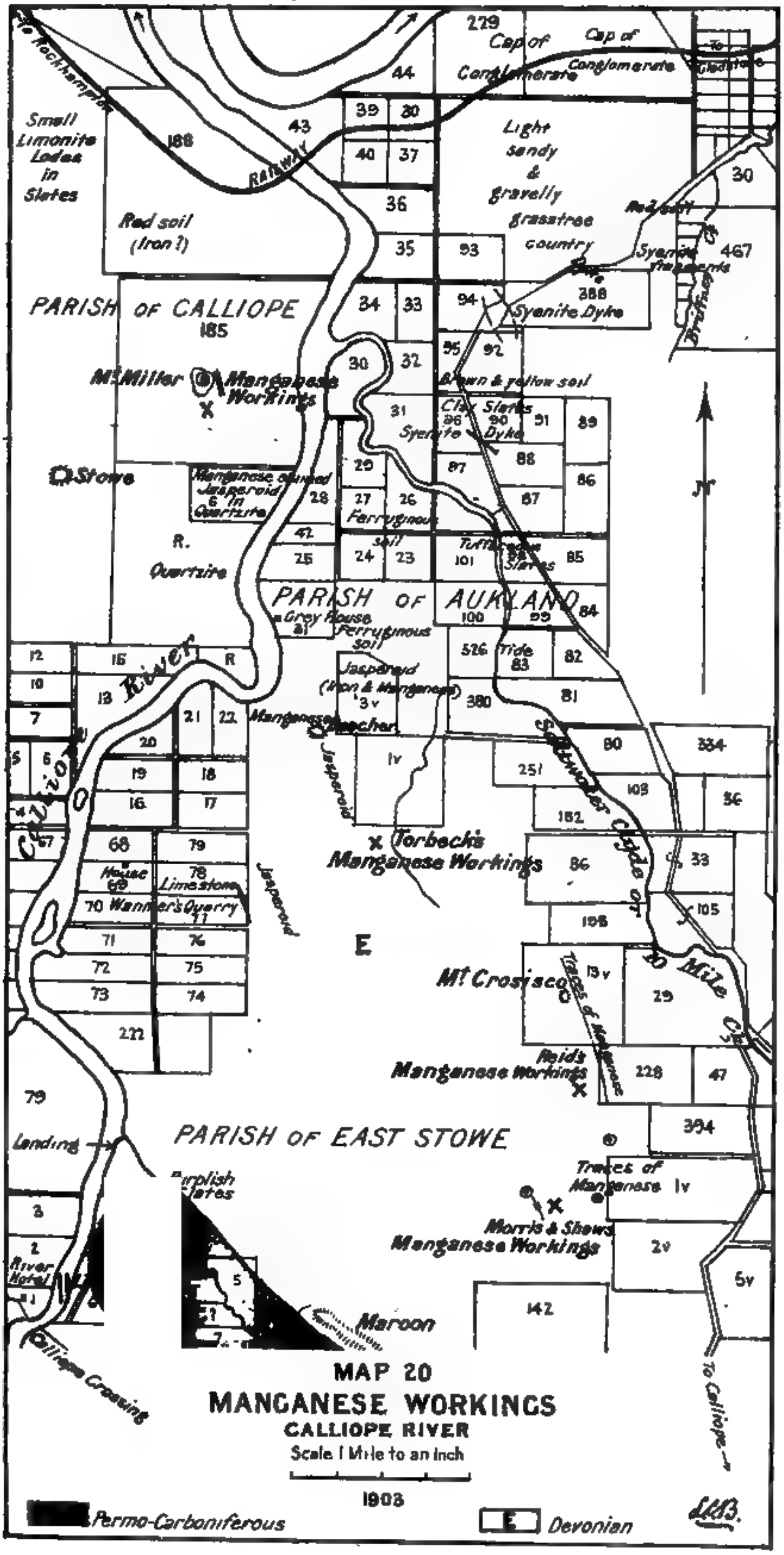
Locality.—Mount Miller is a hill in the centre of freehold portion 185, Calliope. (*See* Map 20.) The workings are near the summit, at an elevation of 400 feet above the Calliope River, from which the mine is one and a quarter miles distant by road. (*See* Fig. 3.) The position is an ideal one for exploitation by means of adits, and the short distances to water and rail greatly enhance the value of the property.

Fig. 3.



History.—The deposit was discovered eight years ago, and has since been held by three separate parties. It has been worked for the last three years by the Mount Miller Mining Company, who employ, besides the mine manager, three men mining, three men breaking ore, and two men picking and bagging. One cart is sufficient to supply the 20-ton cutter which carries the ore to Rockhampton.

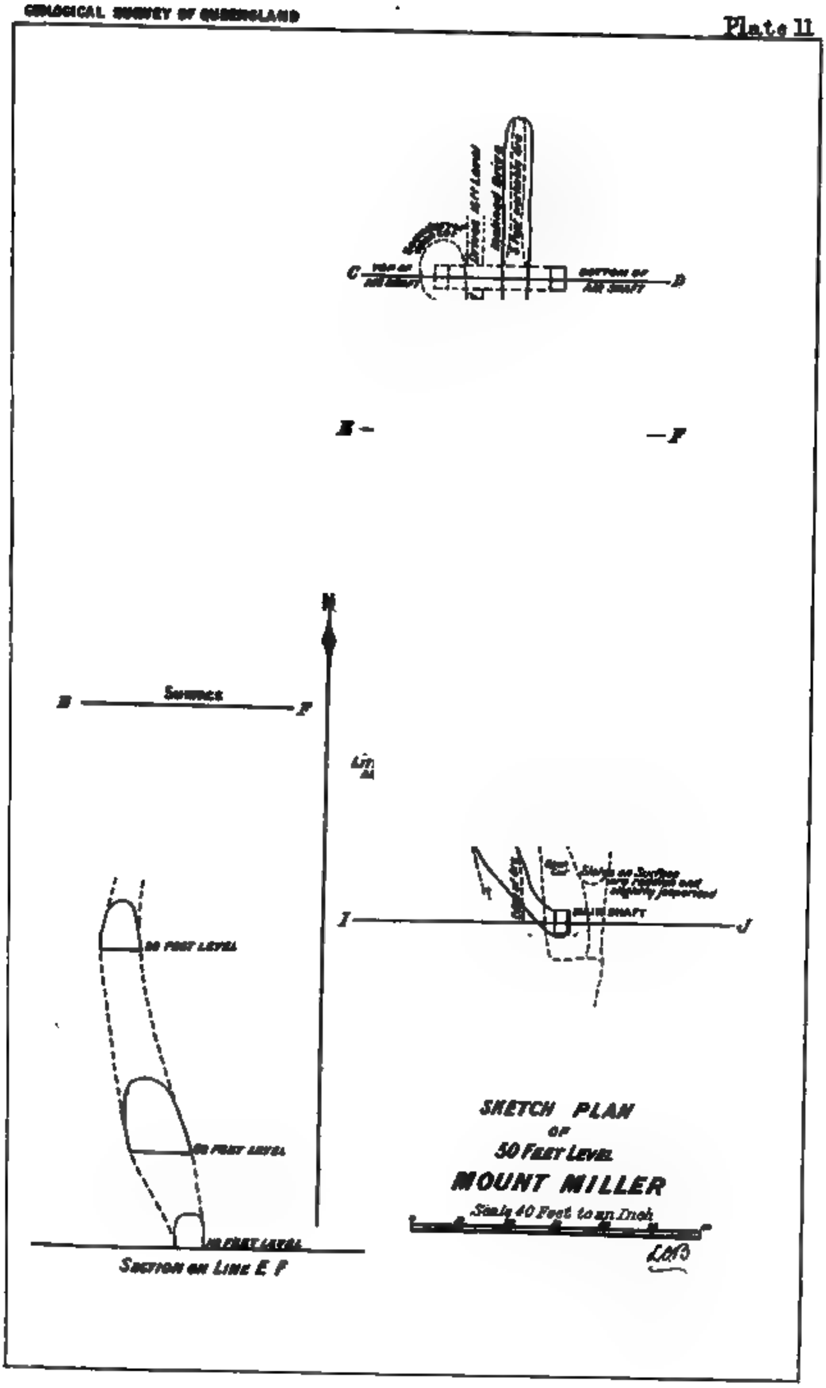
Workings.—The two original outcrops were 60 yards apart, and as attested by the open cuts on their sites, were small. The southern and larger (No. 1) is only 25 feet in length, six to 12 feet wide, and 15 feet deep. (*See* Plate 10.) Reports differ as to the nature of the outcrop, but as it has been practically all quarried out it was probably payable ore. The main shaft has been sunk in this to a depth of 112 feet, and a ventilating shaft (No. 1 air shaft) in the northern open cut, has been connected with it at that level and also at the 50-feet level. (*See* Plates 11, 12, and 13.) The 50 and 112 feet levels have been connected by a third (the No. 2 air) shaft. A winze has been sunk to 50 feet below the 112-feet level at the northern end, and a crosscut connects it with the lode. Large stopes, 25 to 35 feet high, ten to 30 yards in length, and up to 20 feet in width, have been opened between the shafts above the 50-feet and the 112-feet levels.

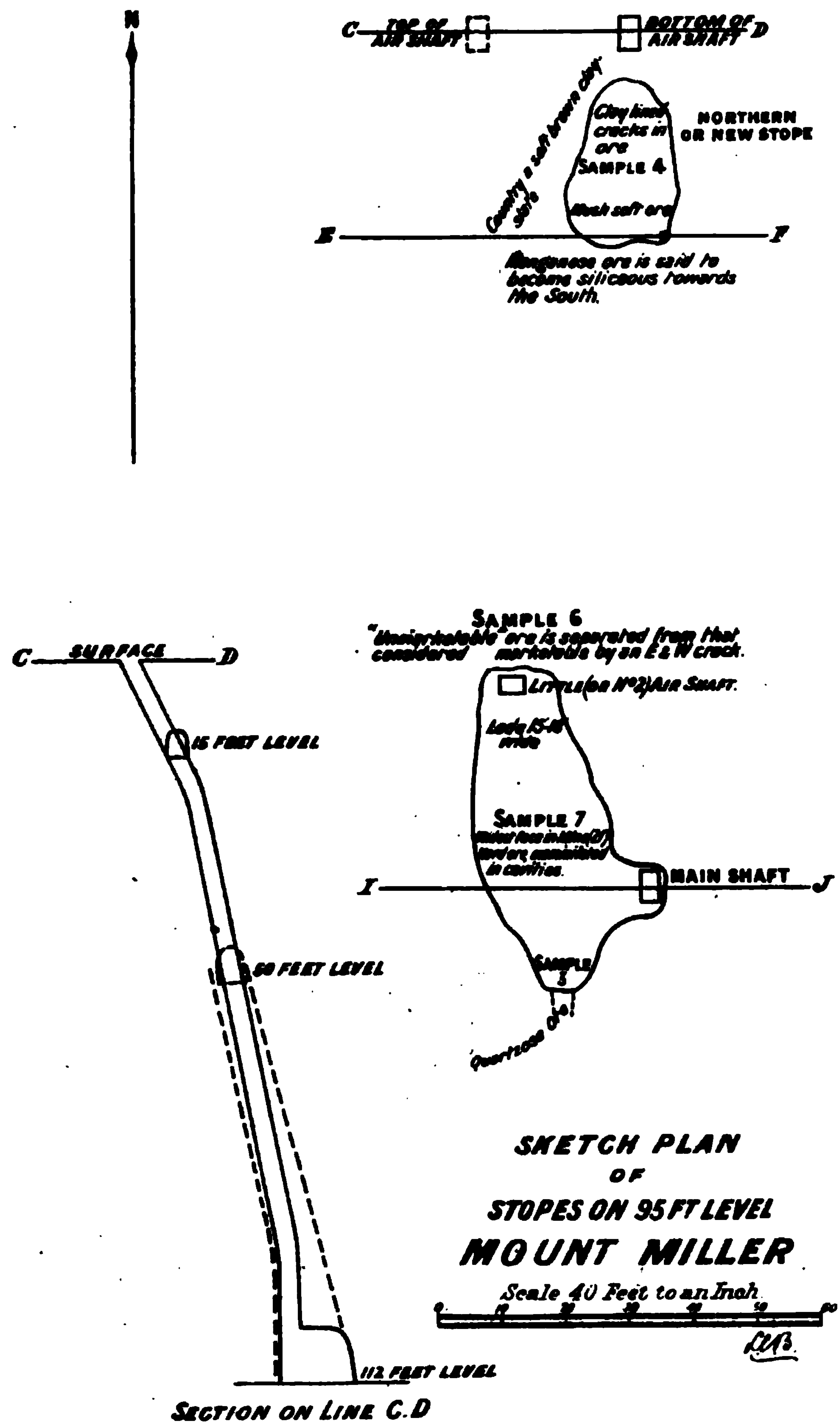


MAP 20
MANGANESE WORKINGS
CALLIOPE RIVER
Scale 1 Mile to an inch
1903

Permo-Carboniferous E Devonian

L.C.B.


C
D
E
F
N
Surface
I
J
MAIN SHAFT
SKETCH PLAN
OF
50 FEET LEVEL
MOUNT MILLER
Scale 40 Feet to an Inch
SECTION ON LINE E F



SKETCH PLAN OF STOPES ON 95 FT LEVEL MOUNT MILLER

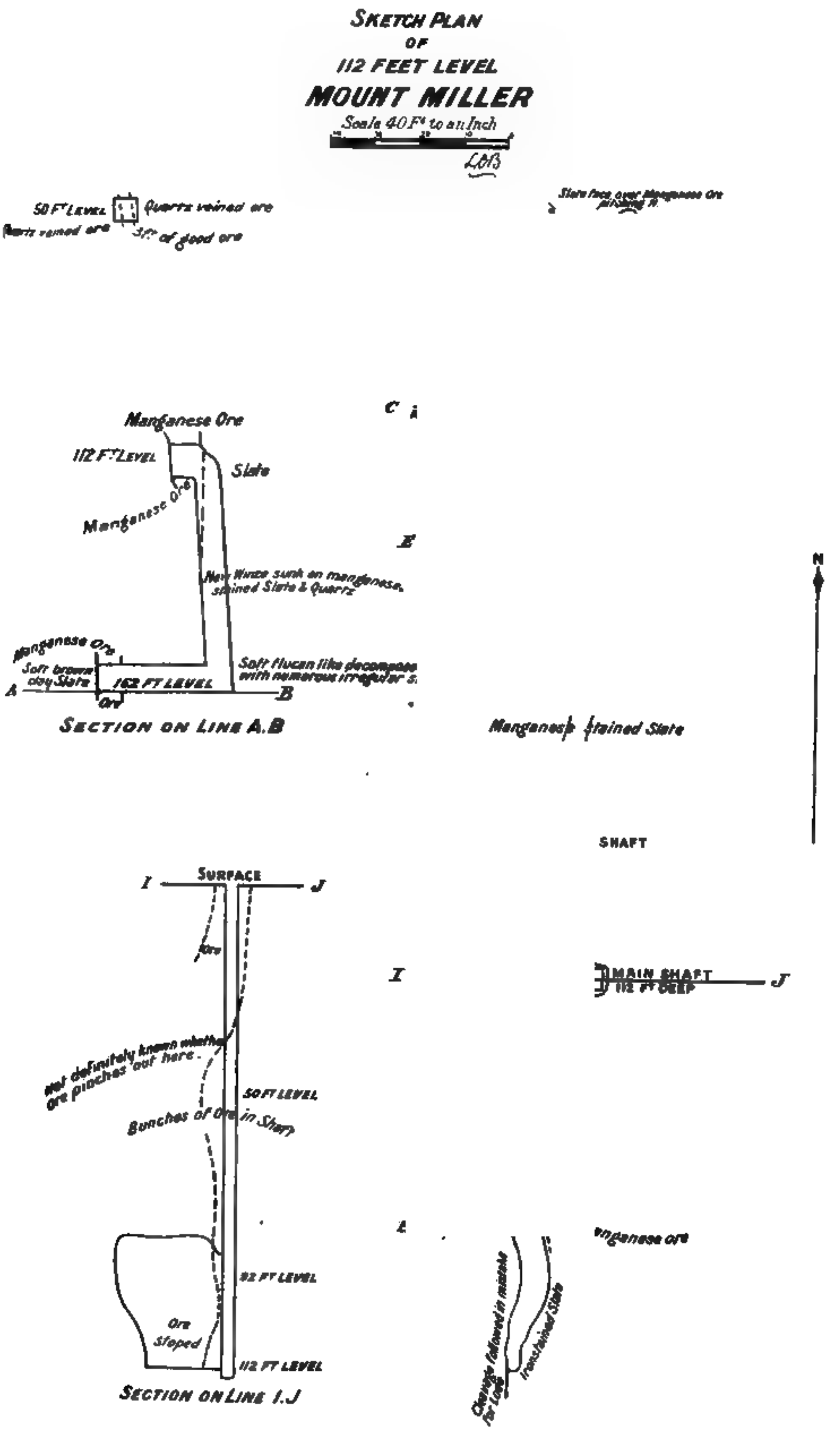

SKETCH PLAN
OF
112 FEET LEVEL
MOUNT MILLER
Scale 40 Ft to an Inch
50 FT LEVEL
Quartz veined ore
3Ft of good ore
Manganese Ore
112 FT LEVEL
Slate
Manganese Ore
New Winze sunk on manganese, stained Slate & Quartz
Manganese Ore
Soft brown clay Slate
162 FT LEVEL
Ore
SECTION ON LINE A.B
Manganese stained Slate
SHAFT
N
SURFACE
Ore
Not definitely known whether ore pinches out here.
50 FT LEVEL
Bunches of Ore in Shaft
82 FT LEVEL
Ore Stoped
112 FT LEVEL
SECTION ON LINE I.J
MAIN SHAFT 112 FT DEEP
Ironstained Slate
Cleavage followed in mistake for Lode

Plate 10.

MOUNT MILLER MANGANESE MINE IN 1902.
(Showing open cut, puppet legs, and sorting shed.)

Photo., L. C. B.

It is proposed to run an adit from the hillside to the northern end of the deposit, at the 200-feet level. This the manager has calculated would be 400 feet long. An adit to the southern end of the deposit would be shorter, but owing to the broken nature of the country there much expense would have to be incurred in making a road.

Prospecting drives have been opened on the 15-feet level and on the 50-feet level (on the north), but beyond that, and continuing the 112-feet drive some 30 yards beyond where payable ore was found, little prospecting has been done. A crosscut to the east from the southern end of the 112-feet level is necessary. It is not definitely known what ore there is between the surface, the 50 and the 112 feet levels, though it could be ascertained by crosscuts from the main and little air shafts. Since my visit the main shaft has been sunk to 172 feet depth, and a crosscut to the west, striking ore within a few feet, continued in it for 29 feet. At the present time (April) drives are being opened north and south in this ore.

Ore Bodies.—As the plans show, the ore body is exceedingly irregular in strike, dip, and thickness. The average strike may be taken as north and south and the dip as vertical or coincident with that of the country.

The thickness of clean ore varies from three feet up to 21 feet. Latest advices report the body on the 172-feet level to be 29 feet in width.

Ore.—The typical ore, chiefly psilomelane but containing pyrolusite, and probably also braunite, is massive, and mostly steel-grey, passing into dull-bluish in bands and patches. It is sometimes honeycombed, and then the cavities are lined with a dead-black deposit of binoxide. At times it has the structure of slate, while in a few cases it is botrioidal and stalactitic, and is then found to be in concentric layers. The hardness of the ore is 6, the fracture is irregular and slightly conchoidal, and the streak is deep-brown and shining. Its specific gravity is 4.1. The ore is singularly free from the clay linings in cavities so characteristic of the ore from most of the other localities, silica and country rock being the chief impurities.

The mine manager has observed that the best ore is found where the country (clay slate) is softest, and thus far its hardness has decreased with depth, it being on the surface a jasperoid (hard, red, and flinty) while in the deepest workings it is a very soft clay slate (little harder than compressed clay).

The present ores may pass into carbonates in depth though no trace of such has yet been found. Even though, as seems most likely, the ore body should pinch at greater depth, another will eventually be picked up on further sinking and crosscutting, as on the 162-feet level.

A table of assays (Government Analyst) of samples taken by me is given below:—

Sample.	MnO_2.	Mn.	Fe.	SiO_2.	P.	S.
1. North end 112-feet level	—	30.3	—	—	—	—
2. South face in 50-feet level (90 feet from air shaft and 10 feet from little air shaft)	57.3	46.4	4.8	12.6	trace	—
4. North stope above 112-feet level (12 feet to 18 feet wide, "all good")	71.0	48 7	1.2	9.1	—	—
6. South stope above 112 feet level "unmarketable'	51.2	41 0	7.2	15.3	0.11	—
7. Face above 112-feet level (20 feet wide)	70.0	48 6	2.5	5.8	trace	trace
8. "Poor ore" thrown over tip	—	45.5	—	14.9	—	—
9. "Pickings' thrown over tip	—	41.0	—	—	—	—
W Bottom new winze (5 feet thickness)	54.1	37.5	4.2	—	—	—

There seems to be some prospect of a market being found for the ore in the United Kingdom in the near future, but at present the whole of the product from this mine goes to Mount Morgan. That delivered during 1901-1902 came from above the 112-feet level, and averaged 73.1 per cent. manganese dioxide. The average for 1902-1903 was the same, the highest assay being 75.8 per cent. (40 tons); the highest in 1903 was 76 per cent. The output during 1902 was the greatest, running from 100 to 120 tons a month, while that during the previous year was 80 tons a month. The lists of shipments received at Mount Morgan, given below, were kindly supplied me by Captain Richard:—

OUTPUT FROM MOUNT MILLER.

Year.	Ore.	Manganese Dioxide.
	Tons.	Per cent.
May to December, 1895	197½	69.66 to 76.84
January to May, 1896	46	65.8 „ 72.94
January to October, 1897	419	55.09 „ 71.91
May to December, 1898	529½	65.60 „ 73.40
January to December, 1899	342	66.40 „ 74.38
January to December, 1900	1,000	66.30 „ 74.70
February to December, 1901	719½	70.50 „ 75.30
January to November, 1902	949½	69.70 „ 75.80
1903	1,350	74.1
	5,553	

The ore on the 172-feet level is proving to be the best yet handled, the latest return (April) having run 79.36 per cent. manganese dioxide.

The approximate value of the ore raised till the middle of 1902 was £15,000.

Treatment.—As the ore has to be bagged for shipment it is considered advisable to spall and handpick it to some extent, in order to raise the percentage of manganese dioxide. Ore in which specks and veinlets of silica can be seen is thrown over the tip, together with a large amount showing crystalline pyrolusite and ore too hard to break up. A sample of the material yields (Government Analyst):—

Manganese	45.5	per cent.
Silica	14.9	„

There must be hundreds of tons of marketable ore in the tip. A sample of pickings from the "fines" thrown on the tip assays (Government Analyst):—

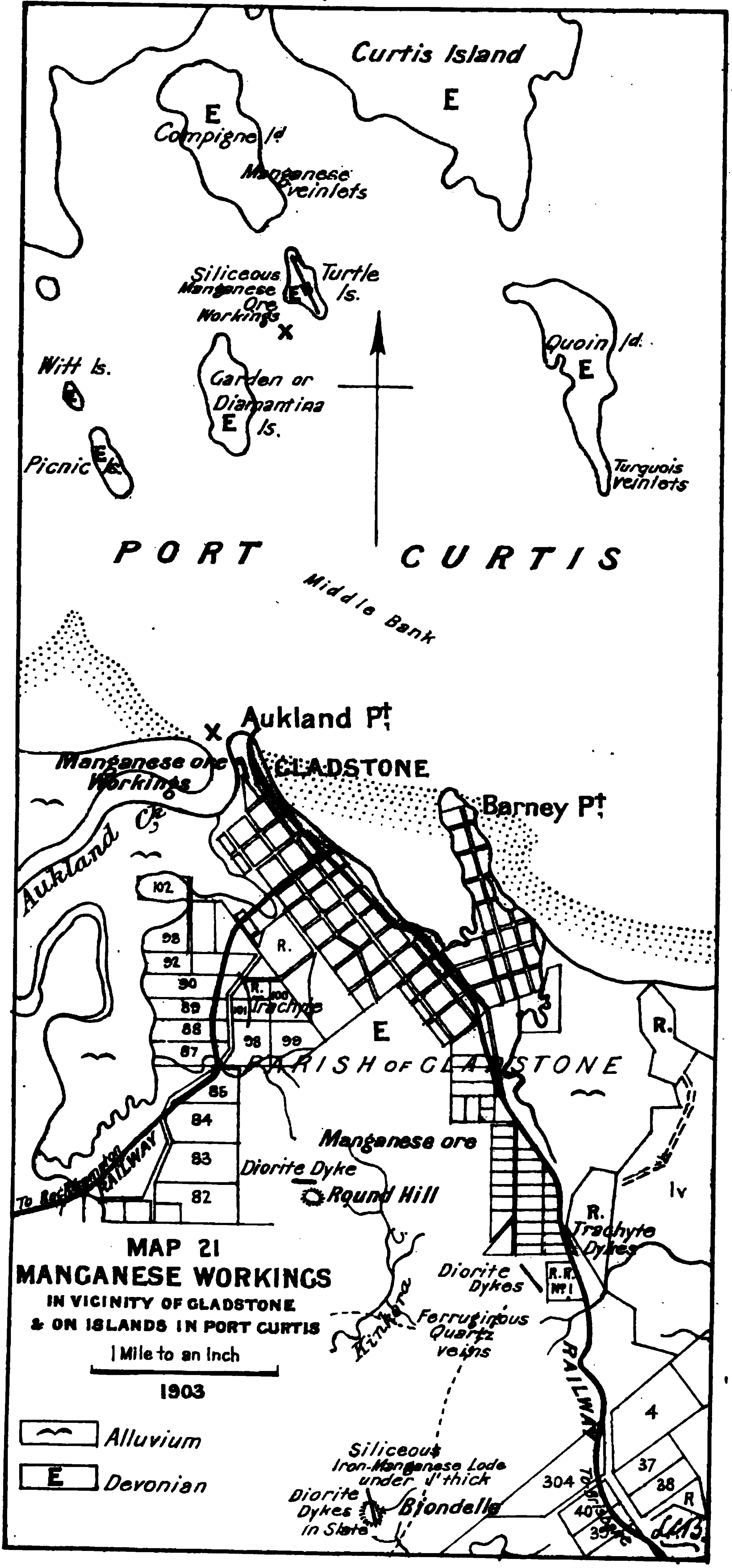
Manganese ... ... 40 per cent.

When the mine was visited the ore was raised by whip and windlass, but steam winding-gear has now been purchased, so that the output can be increased at shortest notice.

The exact cost of mining, sorting, and freight to Rockhampton is not available, but the amount is probably not much more than £1 per ton.

II.—AUCKLAND HILL.

Locality.—Auckland Hill, forming Auckland Point, is the extreme northern end of the ridge on which Gladstone is built. (*See* Map 21.) Although leased for mining purposes it is a recreation reserve, and is known by the Gladstone Municipal Council as Victoria Park. Its area is 12 acres. On the


Curtis Island
E
Compigne Id
Manganese veinlets
Siliceous Manganese Ore Workings
Turtle Is.
Quoin Id.
Witt Is.
Garden or Diamantina Is.
Picnic Is.
Turquois veinlets
PORT CURTIS
Middle Bank
Aukland Pt
Manganese ore Workings
GLADSTONE
Barney Pt
Aukland Ck
102
98
92
90
89
88
87
R.
Trachyte
E
PARISH OF GLADSTONE
85
84
83
82
Manganese ore
Diorite Dyke
Round Hill
To Rockhampton RAILWAY
R.
Iv
R. Trachyte Dykes
Diorite Dykes
R.R. No 1
Ferruginous Quartz veins
Kinkora
RAILWAY
Siliceous Iron-Manganese Lode under 1' thick
Diorite Dykes in Slate
Blondelle
4
37
38
304
40
39
R
To Brisbane
MAP 21
MANGANESE WORKINGS
IN VICINITY OF GLADSTONE
& ON ISLANDS IN PORT CURTIS
1 Mile to an Inch
1903
Alluvium
E Devonian

GEOLOGICAL SURVEY of QUEENSLAND

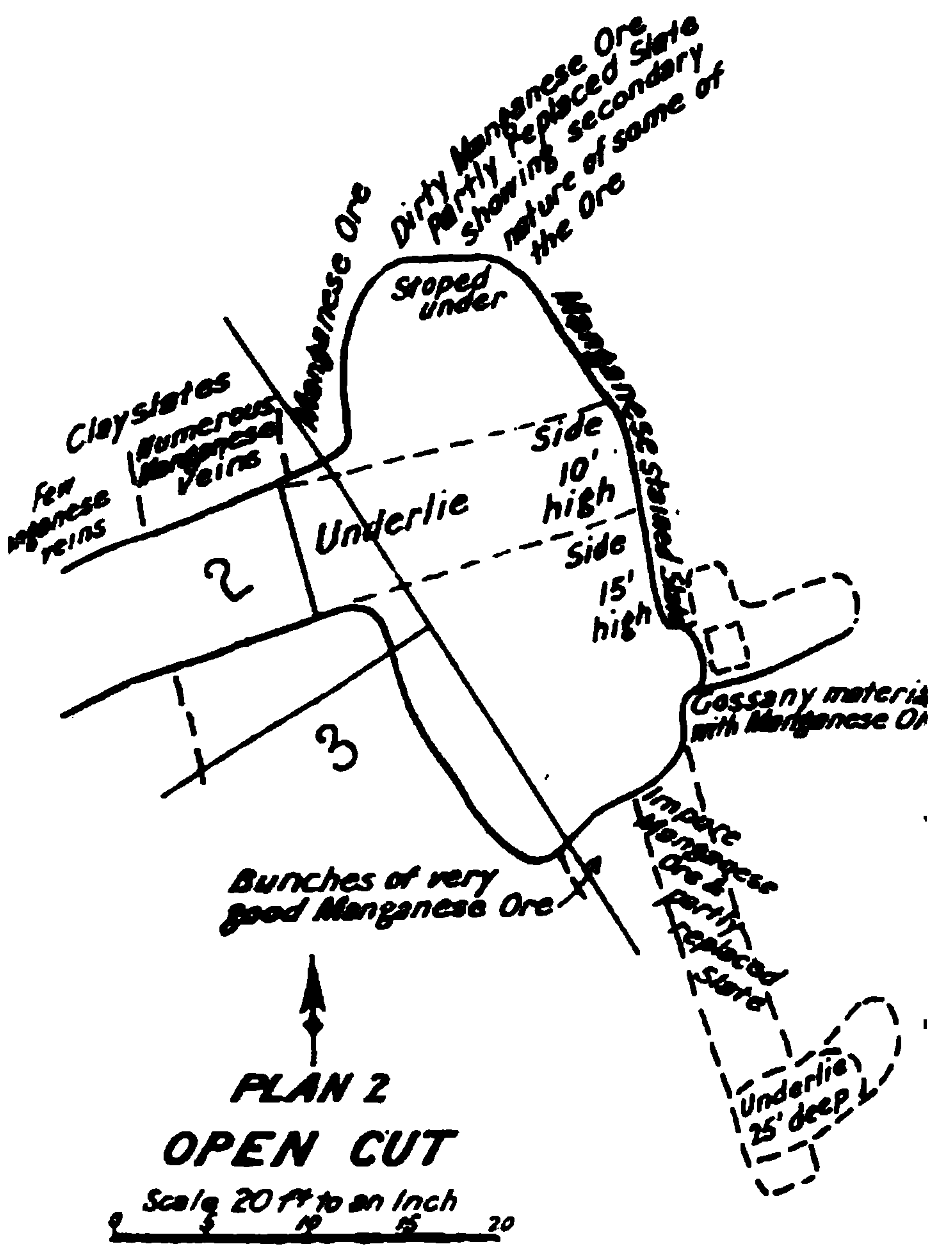
PLAN OF

AUCKLAND

Scale 6 Chains to an Inc

Auckland

AUCKLAND HILL



PLAN 2

OPEN CUT

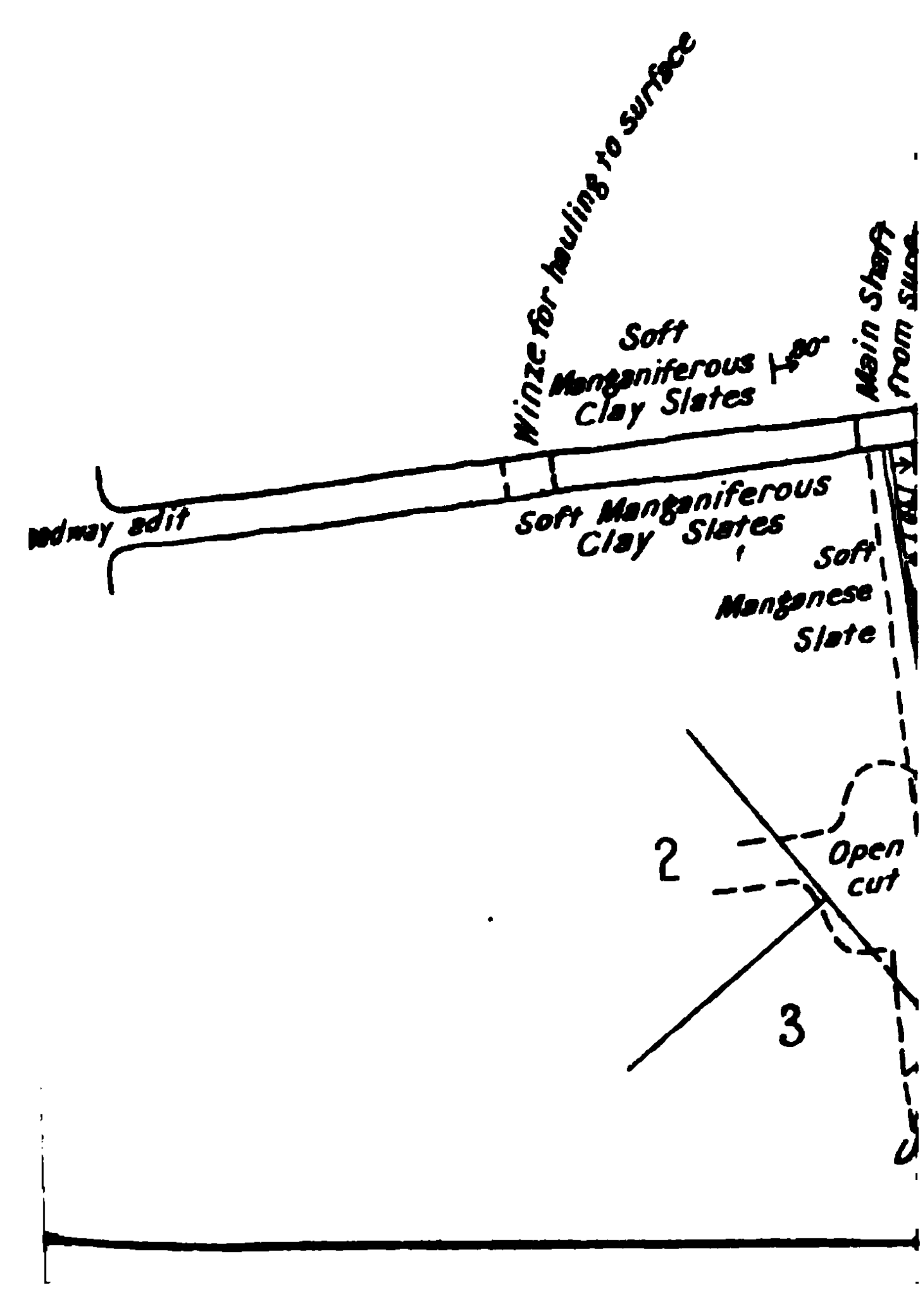


Plate 15.

Photo., L.C.B

AUCKLAND HILL MANGANESE MINE.

(Viewed from the West.)

east is Port Cutris, with the Government jetty for large boats; and on the west is Auckland Inlet, with wharves for the smaller vessels, making the position an ideal one as far as shipping is concerned. (*See* Plan 22.)

History.—Work was first begun here in 1882, with the intention of exporting the ore, but operations had soon to be suspended. The ore has been attacked from time to time since then, principally to supply Charters Towers and Mount Morgan, most of the work being done by the late Mr. Spiro, during 1895, 1896, and 1897. The mine now lies idle in the hands of a Toowoomba syndicate.

Workings.—The main workings (*see* Plate 14) are on the western side of the hill, but one shaft has been sunk on the north, and proved the existence of ore within five chains of the point, and quite lately a pot-hole has been opened in the south-western corner of the park in six feet of slate, partly replaced by manganese ore. An adit was put into the hillside below and a little to the north of this, but failed to find more than a trace of manganese. Therefore that deposit either has the form of a lens or it has "pitched," or it has been faulted. The first is most probable.

The main workings include an open cut with various short crosscourses; an adit 90 yards in length level with the municipal roadway, which is only a few feet above high-water mark; three shafts from the surface; and a main drive 35 yards long connecting the northern and southern shafts.

A general view of the mine is given in Plate 15.

The country consists of soft clay slates, which in places in the main adit are almost free from iron stains, and have been proved to be suitable for pottery.

Ore.—The ore occurred in bunches of up to 20 or 30 tons, connected by stringers. While inspecting the vein in the main drive there was no doubt in my mind that ore has there replaced slate. As the main shaft reaches a little below sea-level, and is only 70 yards from Auckland Inlet, there has been a great influx of brackish water, which has thus far prevented sinking, though it is said the ore in the lower part of the shaft is better than that above the water.

The ore is massive, and consists of a mixture of psilomelane, pyrolusite, and braunite; it has a submetallic lustre and steel-grey colour with brown streaks; its hardness is 5.5, and its specific gravity is 3.8. That raised always contained a considerable amount of clay, and had to be washed before shipment. For this purpose a crude form of rocking-table was employed, being connected by a rod to the flywheel of the engine used for hauling.

The ore exported by Mr. Spiro contained an average of 67 or 68 per cent. manganese dioxide. A shipment of ore from the main shaft, raised by Mr. Torbeck in 1901, ran 77 per cent. manganese dioxide. A sample was taken from the few tons bagged now on the surface: it assays (Government Analyst)—

Manganese	46.7	per cent.
Manganese dioxide ...	69.4	,,
Silica	7.6	,,
Iron	2.2	,,
Phosphorus	0.33	,,
Sulphur	trace	

The phosphorus is objectionally high, if the ore be required for speigeleisen. The element, however, probably occurs in the clayey impurities, which may be expected to decrease below water-level.

The following shipments have been received at Mount Morgan:—

Year.	Ore.	Manganese Dioxide.
	Tons.	Per cent.
May to October, 1895	100	68.55 to 77.63
January to December, 1896	278	56.18 ,, 74.94
January to September, 1897	480	43.6 ,, 72.93
July to September, 1899	117	67.5 ,, 69.87
January to October, 1900	298½	52.65 ,, 77.4
	1,273½	

III.—MORGAN'S AND REID'S.

Locality.—Morgan's workings lie three-eighths of a mile west of the eight-mile bench mark on the Gladstone-Rockhampton Railway Line. (*See* Map 23.)

History.—Morgan began work about six years ago, and during three years obtained a couple of hundred tons of ore. The ground then lay abandoned for two years, when Reid took it up and secured 18 tons 15 cwt. of ore.

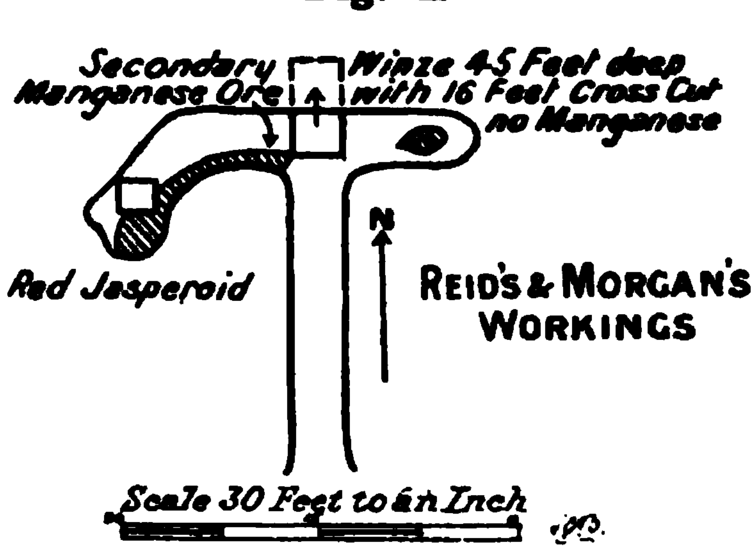
Workings.—A line of trenches and small shafts runs up the side of a ridge in a west-south-west direction for a distance of five chains.

Reid's workings are on the ridgetop, where some of the surface ore is said to have been 5 per cent. better than that at Mount Miller, but much of the ore, though hard and metallic-looking, contained only 40 per cent. MnO_2. The deposit struck north-west, and pitched in the same direction. The country rock here also is a hard red jasperoid slate, with white quartz veins, causing "pseudo-breccia" (exactly the same in appearance as that at Mount Colo, north of Kilkivan*).

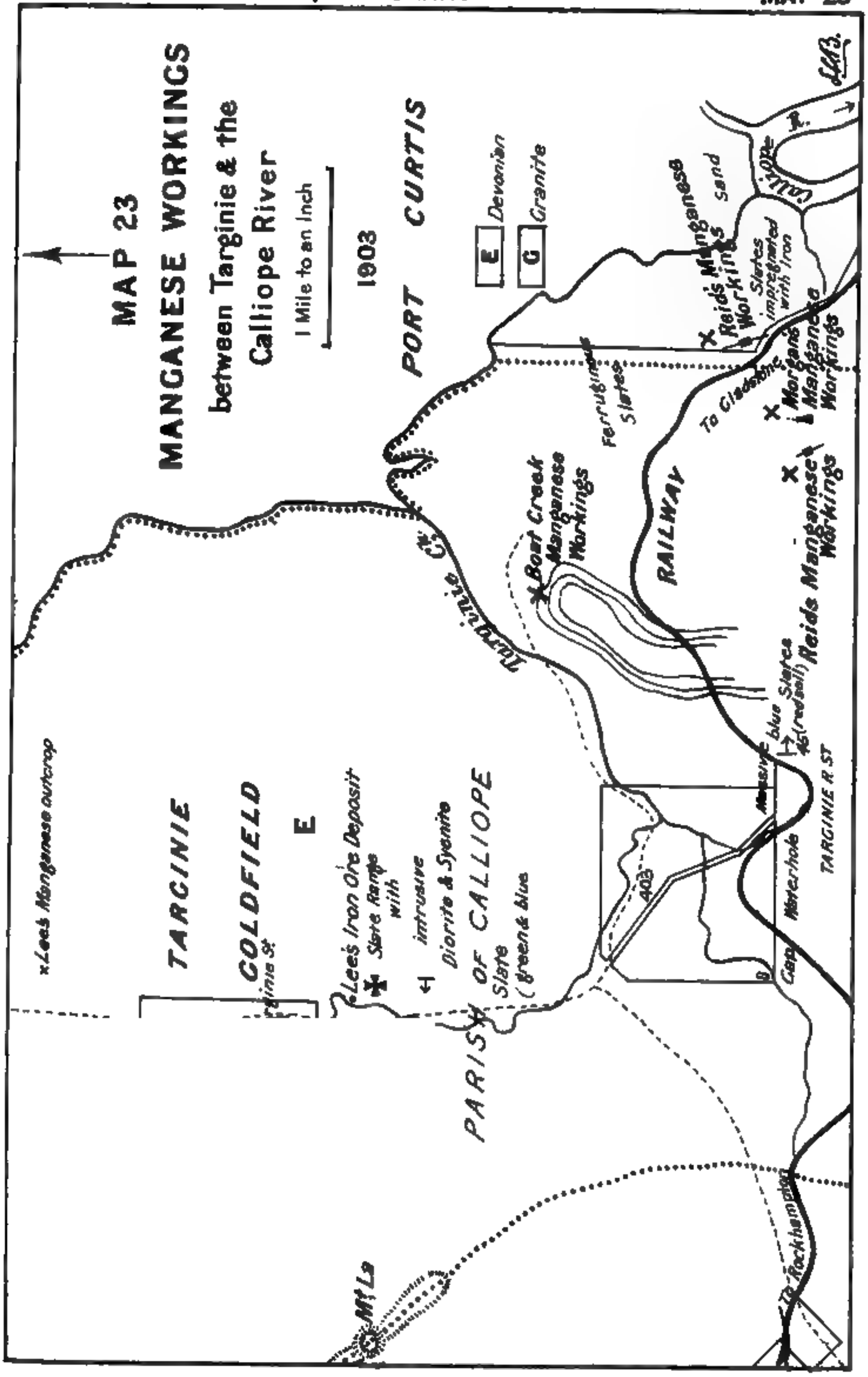
The main shaft is 110 feet deep, with crosscuts 30 feet in length to north and 20 feet to south in country at the bottom. At 70 feet depth is a drive for 12 feet to north-west and 35 feet to south-east, also in country. At 35 feet depth a 15-feet incline drive to the north-west picked up ore at five feet from the shaft, but at the end it became very poor.

About five chains north-west of the main shaft the jasper has been apparently brecciated and infilled with manganese oxides. A few large bunches of ore were worked out by Morgan. Reid opened an adit about 20 feet below one of these, and then connected the old and new workings with a winze. Two bunches of ore were struck, one 15 feet long and one to five feet thick, and one three feet in diameter. They yielded about eight and a-half tons of ore. The sketch appended shows how irregular the deposits were. (*See* Fig. 4.)

Fig. 4.



* *See* G.S.Q. Report No. 179.


MAP 23
MANGANESE WORKINGS
between Targinie & the
Calliope River
1 Mile to an Inch
1903
PORT CURTIS
E Devonian
G Granite
Reids Manganese Workings
Slates impregnated with Iron
sand
Morgans Manganese Workings
To Gladstone
Ferruginous Slates
Boat Creek Manganese Workings
RAILWAY
Reids Manganese Workings
blue Slates
Targinie Ck
TARGINIE
COLDFIELD
E
x Lee's Manganese outcrop
Lee's Iron Ore Deposit
Slate Range with intrusive Diorite & Syenite
PARISH OF CALLIOPE
Slate (green & blue
Waterhole
TARGINIE R ST
To Rockhampton
Mt Ls

Ore.—There appear to have been a number of north and south lenses connected by cross branches, in a red jasperised slate. Ore was never found at a greater depth than 20 feet, and the deposits seem to have been at least partly in a residual clay—*i.e.*, concentrated owing to disintegration and denudation of the country rock. There is a large area of red soil, and tons of shoads are said to have been collected, but ground was broken only where a block outcropped.

The following shipments have been received at Mount Morgan:—

Year.	Ore.	Manganese Dioxide.
	Tons.	Per cent.
August and October, 1897	42½	69.2 to 69.65
April to December, 1898	122½	67.1 „ 72.70
May, 1899	18½	66.43
	183½	

IV.—BOAT CREEK.

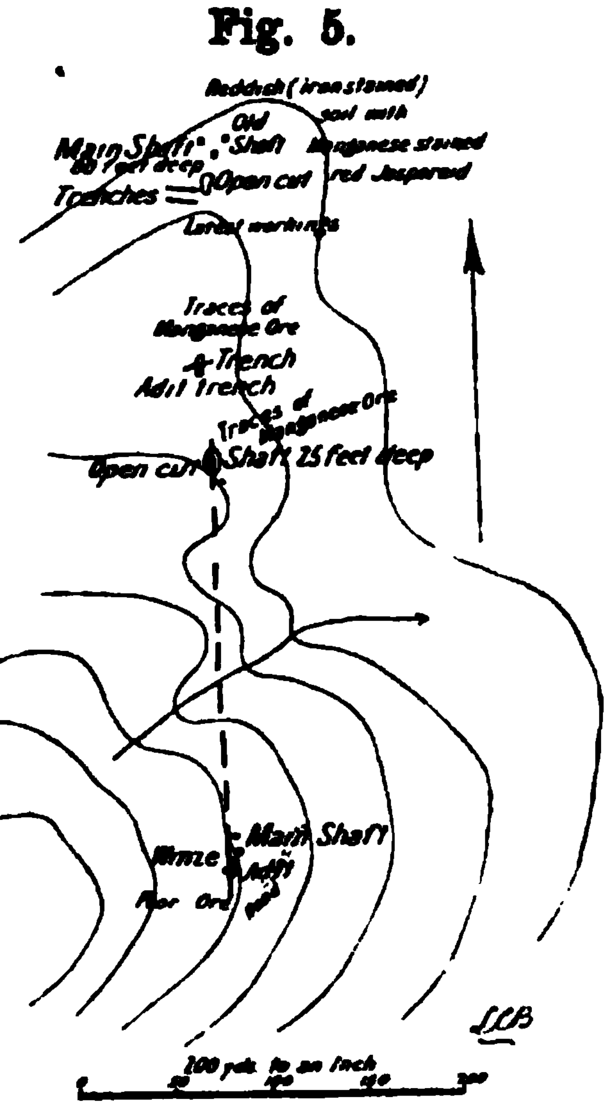
Locality.—Boat Creek workings are on the end of a rocky redsoil spur, about 150 feet above the flats south of Boat or Targinie Creek, seven miles west of Gladstone. (*See* Map 23.) They are now abandoned. A reward claim was taken up by D. McIntyre in May, 1902, but the ground had been held long before that.

Workings.—More trenching has been done on this hill than in the whole of the remainder of the Gladstone district, but no large deposits have been exposed, so the red colour of the soil must be due to iron disseminated in the slates.

It was not possible to examine any of the shafts, as all ropes and ladders had been removed. Very little is to be seen on the surface. The mine was abandoned because operations failed to locate further deposits of ore at a reasonable outlay.

Ore Deposits.—Bunches of ore occurred in two zones connected by manganese-stained country. Some of the ore from here has a better appearance even than that from Mount Miller. Several hundred tons of good ore (lowest 68 per cent., highest 70.8 MnO_2), are reported to have been taken from the latest workings on the north. (*See* Fig. 5.)

Fig. 5.



The following shipments have been received at Mount Morgan:—

Year.	Ore.	Manganese Dioxide.
	Tons.	Per cent.
May to November, 1901	79	65.5 to 69.7
April to August, 1902	65	68.4 „ 70.8
	144	

V.—SHAW AND MORRIS.

Locality.—This deposit lies three and a-half miles due north of Calliope and eight and a-half miles south-south-west of Gladstone. (*See* Map 24.) The distance by road to the landing on the Calliope River is four and a-half miles, practically all down hill.

Workings.—It was discovered three years ago by Cairncross, who held it for six months, and obtained from an open cut about ten tons of ore, which still lies at grass. The ground was taken up later by Shaw and Morris, the original lessees of Mount Miller, and worked for eighteen months. They sank two shafts, still open to a depth of 20 feet, at which level in the northern shaft are a drive for ten feet to the west, and an incline for 40 feet to the east.

Ore.—The ore raised by Cairncross assays (Government Analyst):—

Manganese dioxide ...	69.5	per cent.
Manganese	46.7	„
Iron	2.7	„
Silica	4.5	„
Phosphorus	0.14	„

The following shipments have been received at Mount Morgan:—

Year.	Ore.	Manganese Dioxide.
	Tons.	Per cent.
January to October, 1900	36	69.2 to 71.7

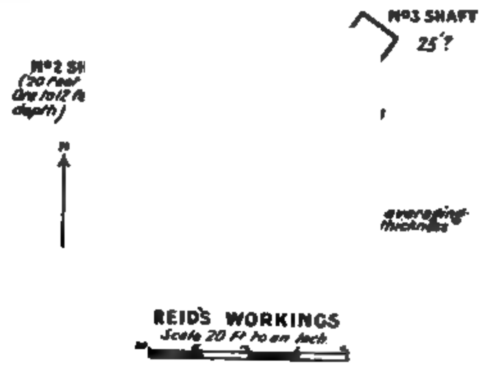
VI.—REID'S.

(*See* Map 12.)

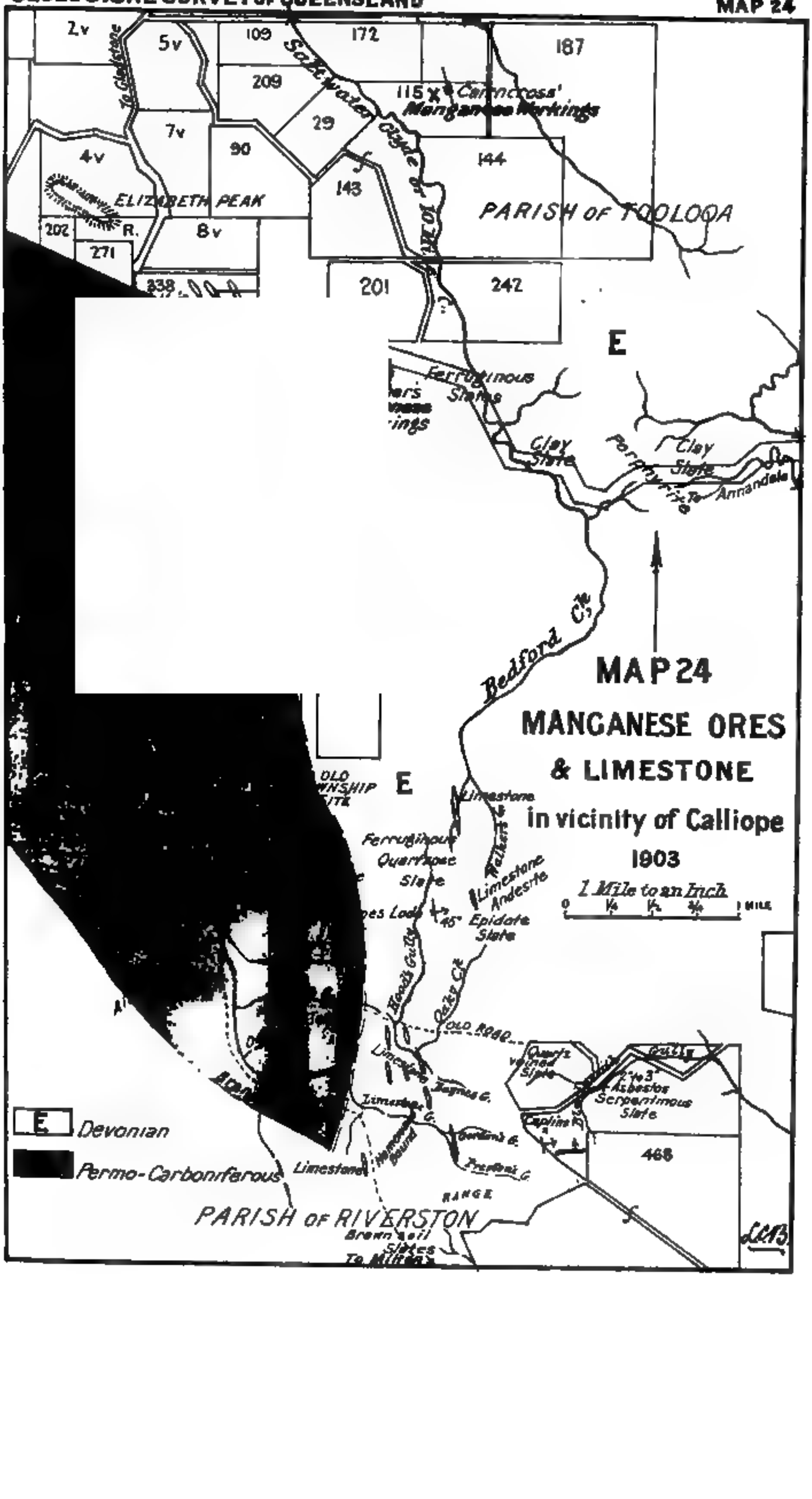
Locality.—Reid's Mine is on the western side of portion 1v, Calliope, about five chains north-east of the railway line, seven and seven-eighths miles from Gladstone. (*See* Map 12.)

Ore Bodies.—Lenticular bodies within 12 feet of the surface yielded 20 tons of good ore.

Fig. 6.



GEOLOGICAL SURVEY of QUEENSLAND MAP 24



Workings.—Two shafts were sunk on the ore bodies, beneath which a crosscut from a third shaft proved only stains of manganese. (*See* Fig. 6.)

VII.—CAIRNCROSS.

Locality.—These old workings are on freehold portion 115, Toolooa, four miles north-east of Calliope and nine miles due south of Gladstone. (*See* Map 24.)

Workings.—The deposits were first worked in 1882, when a shaft was sunk 30 feet, and a pothole one and a-half chains north of it, and on the opposite side of the ridge, was opened.

Ore Bodies.—The ore body in the shaft yielded 30 tons of ore before pinching out in quartzose slate, striking north-west. This ore had to be washed to remove a coating of clay. Another bunch of 15 tons of cleaner ore was obtained from the pothole; this is said to have been vertical, but nothing of it can now be seen. Blocks of ore have been found right to the boundary of portion 172. On the surface the ore is rather siliceous, but it improves at a depth. The ore raised was sold in Gladstone for £3 per ton and thence shipped for Charters Towers.

The cost of cartage to the Calliope River was then 7s. to 8s. per ton and to Gladstone £1, which would now be 10s. or less. The royalty required by the owner of the ground is 1s. per ton.

VIII.—ONE-TREE (OR ROUND) HILL.

(*See* Map 20.)

Martin's (abandoned).—Old workings, about half a mile south-south-east of the Hill. A couple of potholes show iron-stained clay slate, and a little slate partly replaced by manganese ore, and one shows a little impure psilomelane, not however worth further prospecting. There is a small diorite dyke striking north-north-east a few yards east of the workings.

Fry's (abandoned).—These lie north 35 degrees east from the Hill. In one pothole thin bedded clay slates strike north-north-east and dip very steeply to the west-north-west. An underlie shaft was opened for about nine feet on two to three feet of rather poor manganese ore, dipping with the country 45 degrees. The hanging-wall country is friable, but the footwall into which the ore gradually fades is chalcedonic. The ore body is worth prospecting, and an attempt has been made to sink a shaft ten feet from the outcrop, but was given up after sinking a few feet.

Foote's (abandoned).—Within 100 feet of the top of One-tree Hill is a tunnel 100 feet in length, crossing the slates in a direction west by south. The slates dip three in one to the west, and are practically all iron and manganese stained, which accounts for the redness of the soil on the hill. No lode was found.

Jones's (abandoned).—The workings are on the brow of a ridge three-quarters of a mile north-north-west of the Hill. The country is manganese-stained ochreous slate with small fragments of manganese ore. A shaft and several potholes have been opened on small bunches of ore. Trenches are needed to prove whether there is anything permanent here.

IX.—GARDNER'S (CALLIOPE).

Locality.—The outcrop of this deposit is on the one-chain road on the eastern side of portion 364, East Stowe, and just south of the ten-chain road. (*See* Map 24.)

Ore Body.—It consists of four feet of decomposed clay slate with lumps of ore, forming beneath the surface a mass from six inches to three feet in width, apparently striking east and west.

Occasional blocks have been found on the surface for a few chains north and south, pointing to that being the strike. A shaft was sunk vertically on the original outcrop to a depth of 20 feet, and the body was followed on the underlie from 20 to 30 feet depth. Another mass of ore on the south side of the shaft not yet broken into is probably a continuation of the deposit on a north and south line.

Ore.—Much of the ore is practically ironstone, and the best ore on the surface is reported to contain only 55 per cent. manganese dioxide. A sample taken from ten feet depth assays (Government Analyst):—

Manganese dioxide ...	43.6 per cent.
Manganese ...	29.7 „
Iron	22.1 „

X.—TORBECK'S (KIRKWOOD'S, MOUNT BEECHER).

(*See* Map 20.)

Locality.—One mile south-east of Mount Beecher and seven miles south-east of Gladstone.

Torbeck's Ore Body.—A small bunch of ore, on which a vertical shaft is being sunk by Mr. Torbeck, gave way within a few feet to black manganese-stained country rock, found when broken into to consist of chalcedonic and jasperoid slate, with bunches of ore; this forms a belt a chain in length, four to six feet wide, and containing more or less manganese ore to a depth of 20 feet. It strikes north-north-west, and on the surface dips 1 in 4 to the west-south-west. It is proposed to sink and then drive. At a depth of 25 feet in the shaft the dip is changing towards east-north-east, and slight traces of manganese are to be seen at 30 feet depth. There is always a possibility of ore being struck in such country as this, but there is nothing very promising here as yet. Only five tons of ore have been obtained, and represent perhaps ten per cent. of the material removed.

Kirkwood's Workings.—Four chains south of Torbeck's shaft is a pothole on a small manganese deposit striking north-north-east and dipping east-south-east (perhaps only locally). Thickness is as much as a foot in places, but in others the ore fades into red jasperoid slate.

The footwall country is soft red clay slate, streaked with white in a similar manner to the footwall country near the little air shaft in the Mount Miller Mine. This deposit may open out, but it gives no definite promise of doing so.

Kirkwood's old shaft is on a vertical fissure, ten feet east of this pothole. It is 50 feet deep. At the surface the eastern wall is vertical and plain, but the western wall is often replaced with iron and manganese.

Ore.—About ten tons of ore from Kirkwood's shaft lie on the surface; blocks of it up to a foot in diameter have the structure of slate, and are probably metasomatic after it. An analysis of a sample of the picked ore is (Government Analyst):—

Manganese dioxide ...	54.4 per cent.
Manganese	37.7 „

XI.—MOUNT CROSISCO.

Locality.—Mount Crosisco (*see* Map 20) is in the centre of portion 13v, East Stowe, eight miles south-south-west of Gladstone.

Country.—Red jasperoid and manganese-stained and replaced slates, striking north-north-west, outcrop and produce a reddish-brown soil for a couple of hundred yards down the northern side of the mountain. The country is worth prospecting by trenches.

Reid's pothole is on manganese-bearing jasperoid, about five chains south of portion 13v, and ten chains from portion 228. There are traces of manganese in jasperoids about ten chains south-west of this. The country here is serpentinous slate, of a different character to any seen elsewhere in the district. The whole locality is worth prospecting, though very little ore is to be seen.

XII.—TARGINIE.

Locality.—Manganese ore (a single block weighing about a hundred-weight), was found a mile north-east of Targinie township, on the northern end of a low ridge. (*See* Map 23.)

Ore.—The ore is massive, black, and glossy, with a strong conchoidal fracture, and a black and shining streak. Its hardness is 6.5, and its specific gravity 3.7. Specimens of red jasperoid, partly replaced by quartz, are found on the surface.

Workings.—A shaft has been begun in decomposed reddish and purplish slate, which five feet from the surface is stained with manganese. Owing to the good quality of the ore it is worth sinking a shallow shaft here to prospect the ground.

XIII.—ISLANDS IN PORT CURTIS.

Traces of manganese are to be found on several of the islands north of Gladstone. (*See* Map 21.)

On the highest point, and in the centre of Turtle Island, a small quarry has been made on a band of slate ten feet wide, and partly replaced by manganese and quartz. The ore obtained was probably payable, but none that now remains could be utilised for any purpose.

On the east side of Compigne Island, and at the south end of Picnic Island, are numerous half-inch veinlets of very good manganese ore, but nothing workable.

Indefinite rumours are also heard of manganese on Curtis Island, which was not visited.

XIV.—KROOMBIT.

In the vicinity of the old furnace area at the Five-mile Copper Mines, already referred to, several fragments of manganese ore were observed. No prospecting has, however, yet been done for deposits of the ore.

4.—CONCLUSION.

I.—*Markets.*

At the present time there is in Queensland a limited local demand for high-grade ore (70 per cent. MnO_2) only, which has been easily met by the one mine now working in the Gladstone district. The demand is that of the

Mount Morgan Gold Mining Company, who require the dioxide for the generation of chlorine, 100 tons a month sufficing at present. The company, naturally not wishing to be dependent on one mine, has greatly encouraged prospecting in this as well as other districts. Thus far the results in the Gladstone district have been disappointing, the deposits found, with the exception of the Mount Miller, proving small and irregular. From their nature the deposits must always be considered difficult and uncertain, as well as expensive to work on any scale.

Imports of ore have been made by the Mount Morgan Company from New Zealand and Java, but the shipments always contain much less dioxide than the first samples sent, and the company consider the local supply the best procurable.

Prospecting in the past has been for ore for this market only, but when steel-works are erected in Australia there will be a strong demand, even for ore such as that at Gardner's, Calliope, low in manganese, but high in iron.

The only other local demands for manganese ores are potteries, chemical works, and smelters, but their total consumption is very small.

Doubt is often expressed locally as to the possibility of working the local deposits, owing to the immense quantitites in Russia and Brazil, but there is encouragement in the consideration that these are never all high-grade ore, well situated, nor suitable for all industries. Then, as in Russia the railway freights are very high, and deliveries are so uncertain that many consumers are glad to buy elsewhere. In Brazil the deposits are over 200 miles from the coast, freight thus eating up much of the profits.

II.—*Value of the Ore.*

In the home markets manganese ore containing over 50 per cent. manganese has been quoted during the last few years at about—generally a little less than—1s. per unit. The English quotation for January, 1904, was 9¼d. per unit, and the American 1s. 0½d., for 50 per cent. ores containing less than 8 per cent. silica and 0.1 per cent. phosphorus. With these values it would require 55 per cent. ore to pay expenses alone (putting mining at 10s., cartage at 5s., and freight to England at 25s.). As there is no likelihood of special vessels being chartered, owing to the available supply being insufficient, we have no present prospect of an extensive export trade.

I should like to acknowledge the assistance rendered by many people in the district, especially Messrs. Torbeck, Reid, Miller, Baker, Fisher, Cairncross, and Gardner.

III.—MARYBOROUGH DISTRICT.

A—Iron Ore Deposits.

1. MOUNT BIGGENDEN.*

Locality.—The mine lies five miles south of Degilbo, and is four and a-half miles by road from Biggenden Railway Station, which is 54 miles from Maryborough. Howard, the centre of the Burrum Coal Field, is 72 miles distant by rail.

Amount.—The amount of iron ore actually proved by the workings is only about 80,000 tons, but very little prospecting would be necessary to expose a much larger quantity.

Workings.—(*See* plans given with Report quoted.) The worked ground is included in an east and west direction, within three and a-half chains, and in a north and south direction within seven chains. The workings consist of three open cuts, an adit, a main shaft, and various drives and crosscuts. The main shaft is 150 feet deep.

Ore.—The main deposit consists of magnetite with patches of calcite and disseminated bismuth ores. A belt of slate ten feet thick on the west separates the main magnetite outcrop from a smaller one. There is another body, not worked, east of that exposed in the main open cut. The magnetite shows no thinning at the 145-feet level.

Treatment.—Being raised for gold and bismuth, at the present time, the ore is hand-picked to a limited extent at the surface. After crushing, the pulp from the mills is washed over Frue vanners, the concentrates from which are dried on a furnace and fed into a magnetic concentrator of the revolving-cylinder type, with a capacity of seven tons vanner concentrates per 12 hours. The magnetite thus separated is practically free from impurities.

The amount of limestone in the immediate vicinity of the mine is unlimited, one bed a few chains to the east being 30 feet across, and extending for a quarter of a mile, with a proved depth of 145 feet.

The gold and bismuth separated magnetically from the iron should pay for the cost of crushing and separating a very pure iron ore for the furnaces.

2. GAYNDAH.

The range top, five miles south of Gayndah, is capped in places with a considerable thickness of laterite, altered in places into limonite and turgite. One of these caps was lately taken up as a prospecting area for gold and silver. It is a curved plateau, 15 chains in length and up to five chains wide, the greater part of the surface of which, as well as much of the slopes, is covered with blocks of limonite and turgite (hydrated sesquioxide of iron), varying from dull-brown to bright-red, and from a soft powder to a compact solid. At several points a white aluminous rock can be seen, either filling pipes in the limonite or else as blocks with joints filled by that mineral; but practically 95 per cent. of the outcrops are iron ore. The deposit may, for the talus hides

* Mount Biggenden Gold and Bismuth Mine. By L.C.B. 1902. By Auth.: Brisb. G.S.Q.P., No. 173.

the lower part, have a maximum thickness of 50 feet at the southern end, gradually tapering out to the north-west in thickness as well as in width. Thus there should be over a million tons of ore here.

A general sample from the whole surface assays (Government Analyst):—

Iron	33.4
Silica and insoluble ...	35.7
Phosphorus	0.1

The lower ridge running north from the above is also capped with limonite.

The limonite rests on flat-bedded white cherty sandstones and shales, which will probably prove to be of Cretaceous age. Similar rocks exist as far south as Brovinia Creek, and as far west as Dykehead—in fact, cap the greater part of the intervening country. Limonite, perhaps less pure even than that at Scotland's Hills, occurs at a great number of localities in this area; and all grades, from the pure mineral through ferruginous beauxite to only slightly stained beauxite can be found. My opinion is that these limonites represent the residuum of former beds of volcanic tuff or mud, or even lava, and that they belong to the Cretaceous beds with which they are always associated.*

B—Limestones.

1. DALESFORD.

Dalesford is a siding on the Bundaberg-Mount Perry Railway Line, 36 miles from the former place, and 31 miles from the latter. All the limestone deposits hitherto worked are within a distance of five miles to the south-south-east of the station.

Portion 1317, Walla (Toban's).

Three main lines of limestone occur in the south-eastern corner of the portion, five miles south-south-east of Dalesford Railway Station.

The country rock is highly-altered slightly-contorted clay schist, with intercalated lenses of quartz, and it is noticeable that where quartz is most strongly developed limestone is absent, and *vice versâ*; in only one place in the district was quartz seen in association with limestone. The dip—45 degrees to 60 degrees—varies from south-south-west to south-west.

The main body of limestone here is over a chain in width, and is traceable for about five chains, when towards the north it gradually tapers out, while towards the south it is covered with detritus. A quarry, a chain in diameter (ten chains from the south-eastern corner of the portion), has been opened to 15 feet depth on this outcrop, and exposes a bed of limestone 15 feet thick, with 25 feet additional limestone, including bands of schist. The limestone is bluish and laminated and in places is very impure. Part of the stone quarried was burnt in an adjacent kiln dug out of the hillside.

Another quarry (15 feet deep and a chain long) five chains west of the above, is now worked; the bed varies from ten feet to a chain in width, within a distance of three chains, and the dip is here 50 degrees to the west.

The limestones contain absolutely no trace of fossils, and though now massive show traces of thin bedding. Before breaking the rock it is impossible

* Reported Gold Find at Scotland's Hills, near Gayndah. By L.C.B. *Queensland Government Mining Journal*, March, 1904, vol. 5.

to distinguish it from the slate, and it probably represents a metamosatically replaced sediment. It contains pyrite in places, which, though an advantage at Mount Perry, would be objectionable for steel-making.

In July last 3,000 tons had been sent away, and of this 1,000 tons went to the Milaquin Sugar Refinery. Much of this material was obtained from the original outcrops.

The cost of quarrying is 2s. 3d. per ton, and of cartage to Dalesford 6s. The central mill tramline now reaches to within one and a-half miles of the quarries, and it may in the future be worth while to extend it to them.

Portion 7V, Walla (Stevens's).

Stevens's quarry lies about half a mile south-west of Toban's. It is only ten feet across, though the limestone, which is slightly more homogeneous than Toban's, is 30 feet wide and three chains in length. Other outcrops can be picked up for miles to the south.

This is the only place where limestone and quartz were found in contact. The country is clay schist, with large blows of hungry white quartz containing films of secondary muscovite on cracks. This quartz near the quarry gives way quite suddenly to limestone.

The best limestone from here has assayed 96 per cent. calcium carbonate, but a little is so stained with oxides of iron and clay that it is useless.

Stevens's Mineral Selection.

This lies about ten chains south of the last quarry. On the surface the stone ten yards across is almost white, but becomes dirty-blue at 15 feet depth. The limestone here gives way in the most abrupt manner to slate, opposite sides of joints being slate and limestone. This is further evidence of replacement.

It is reported that there are numerous other outcrops of limestone south of this, and there is thus probably a belt extending down to Tenningering Head Station, where limestone is known to occur in large quantities, but owing to its geographical position, quite unavailable at present.

Portion 1230, Walla (Thiel's).

The limestones are in the eastern end of the portion, half a mile west of Toban's quarry. The strata here strikes north and south, and dip 80 degrees to the west. The limestone seems to have developed on the northern side of a fault striking west-north-west. It varies from light-blue to yellow in colour, and has every appearance of having replaced thin bedded slates. Slabs six inches thick and two feet six inches square can be obtained without any trouble.

A quarry three chains long and one chain in width is now being worked, but outcrops of limestone occur for over two chains to the east, and again five chains to the north-east is another bed of deep-blue limestone. During the fifteen months previous to my visit 7,000 tons of stone had been sent away, while the total exported from the whole district was computed as 10,000 tons, valued at £4,000.

Other Outcrops.

On the Crown land two miles south-east of Dalesford several claims have been pegged out, but the limestone beds here, which are vertical, and strike north and south are generally, as far as proved, less than three feet in thickness.

The stone is, however, variously coloured—pink, blue, and green—and would, if in quantity, be of value for building purposes. The country rock is chloritic schist with disseminated octahedral crystals of magnetite.

2. BIGGENDEN AND DEGILBO.

Considerable beds of limestone occur in a belt running south from Biggenden and Degilbo* (the latter the terminus of a railway from Maryborough).

Though large quantities of stone sufficiently pure for lime-making can be had between the two towns, the greater part of the deposits is rather impure. This would, perhaps, be rather an advantage than otherwise in a flux. The limestones near the Biggenden mines are often garnetiferous, and admirably adapted for fluxing.

3. GIGOOMGAN.

There are in the neighbourhood of Gigoomgan Head Station large outcrops of limestone of all degrees of purity, from marble to calcareous shale.†

A belt of more highly altered limestone occurs to the south of this, midway between the Degilbo and Kilkivan branch railways.‡

C—Manganese Ore Deposits.

1. GIN GIN.

The manganese deposits in the Gin Gin district have been dealt with in detail in a separate report.§

Very little work has been done on the deposits as yet, the outcrops only having been tested, and they average considerably below 70 per cent. manganese dioxide. There is, however, promise of the deposits increasing in size and quality below the surface.

2. DEGILBO.

The deposits in this district are referred to in the above report. Though the ore is slightly richer than that at Gin Gin, the quantity apparently available is only a few tons.

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* G.S.Q.P., No. 173.

† Annual Notes. L.C.B. *Queensland Government Mining Journal*, June, 1903, vol. IV.

‡ Report on Yorkey's Gold Field and the Marodian Gold and Copper Field. By L.C.B. Bris. By Auth., 1902. G.S.Q.P., No. 179.

§ Some Manganese Deposits in the Gin Gin, Degilbo, and Warwick Districts. By L.C.B. Bris.: By Auth., 1903. G.S.Q.P., No. 189.

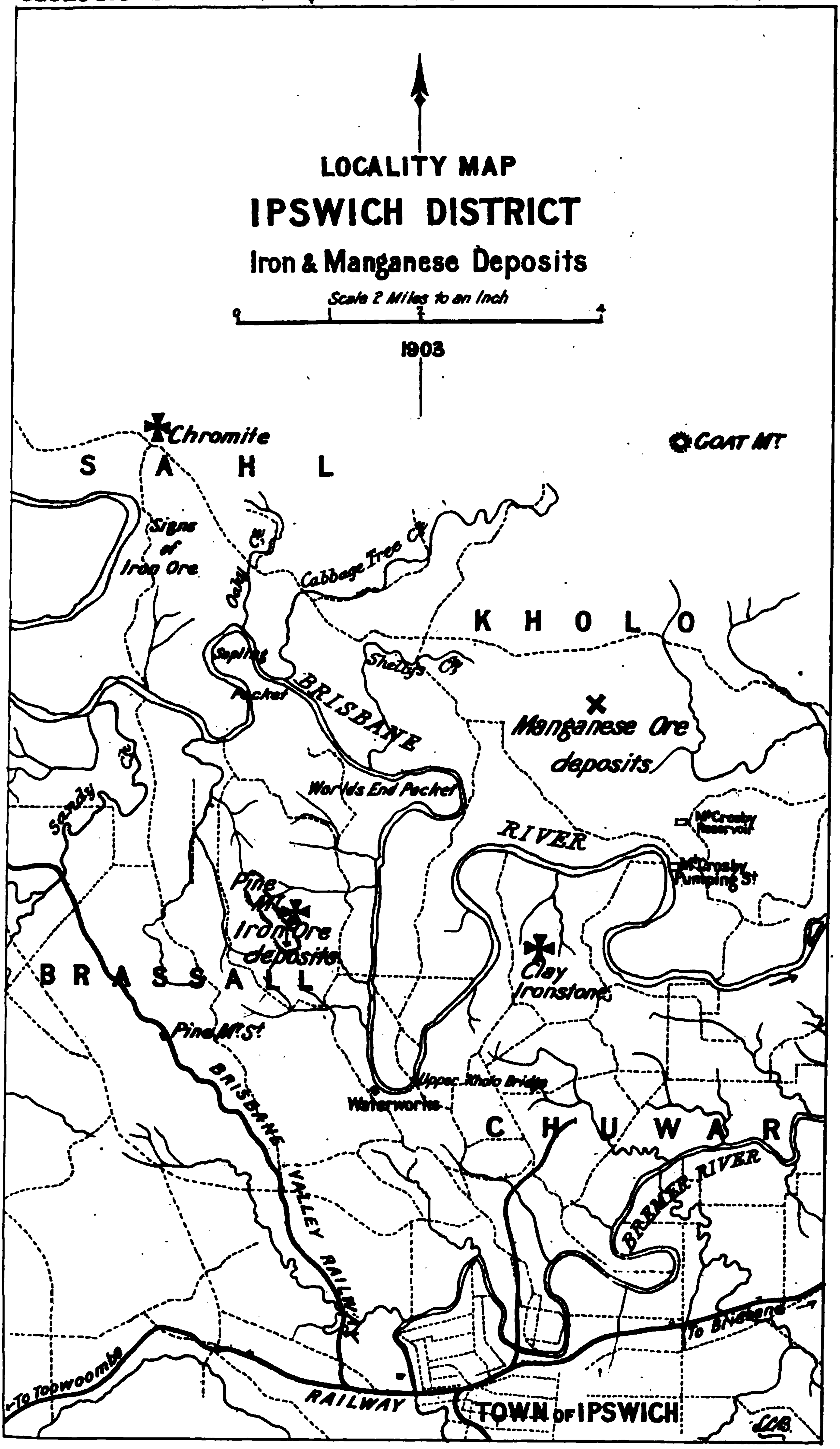

LOCALITY MAP
IPSWICH DISTRICT
Iron & Manganese Deposits
Scale 2 Miles to an Inch
0 1 2 4
1903
Chromite
GOAT MT
S A H L
Signs of Iron Ore
Oaky Ck
Cabbage Tree Ck
K H O L O
Sapling Pocket
BRISBANE
Manganese Ore deposits
Sandy Ck
Worlds End Pocket
RIVER
McCrosby Reservoir
McCrosby Pumping St
Pine Mt
Iron Ore deposits
Clay Ironstone
B R A S S A L L
Pine Mt St
BRISBANE VALLEY RAILWAY
Upper Kholo Bridge
Waterworks
C H U W A R
BREMER RIVER
To Brisbane
To Toowoomba
RAILWAY
TOWN OF IPSWICH

Plate 16.

Photo., L C B.

PINE MOUNTAIN, FROM THE WEST.

(Showing Russel's Workings in paddock in middle distance.)

IV.—IPSWICH DISTRICT.

Locality Map 25.

A—Iron Ore Deposits.

1. PINE MOUNTAIN.

Locality and Topography.—Pine Mountain is a ridge three miles in length in a north and south direction, and at its base a mile in width; the highest point, near the southern end, is five miles north-north-west of the Ipswich Railway Station. (*See* Plate 16.)

It forms a distinctive feature in the landscape, there being no other elevated ground within many miles in all directions. The slopes of the mountain itself are exceedingly precipitous, but the foothills are generally smooth and rounded. The mountain, with the slate country round it, was formerly covered by a dense growth of scrub, patches of which still exist, especially on the north. The scrub growth is due in the first place to the great richness and open nature of the soil, but it has probably been influenced by the water-bearing character of the country rocks.

The mountain owes its existence to belts of quartzite, which have proved more resistant to atmospheric denudation than the ferruginous clay slates, ore bodies, serpentine, &c., round about it.

The term Pine Mountain now includes the closely settled district round the base of the mountain proper. The land was taken up in the very early days, and is now all freehold.

The most striking feature of the district is the redness of the soil on the slate country, the intensity varying from very deep-maroon to light-brown.

Former Reports, &c.—Iron ore has been noticed on the south-west side of the mountain ever since the land was taken up, and several experts from England are reported to have visited the district to inquire into the matter. Mr. William H. Rands, then Assistant Government Geologist, inspected the district is 1894, specially with regard to the discovery of gold and iron ores. The following extracts are taken from his report:—*

"The most westerly bed of the Pine Mountain series is a soft greenish mottled serpentine, which I traced in a north-north-westerly direction from Jackson's selection No. 276 for a distance of about two miles. Lumps of chromite (chrome iron ore). have been picked up on this serpentine area; the greater number of pieces appear to be in the neighbourhood of selections Nos. 536 and 541, taken up in the name of A. W. Knox. I found one piece that must have weighed over half a hundredweight. The chromite has only been found in lumps on the surface, and not *in situ*. From the position of the pieces it is probable that if any regular deposit is found it will be near the summit of the ridge formed by the serpentine (which lies to the west of Pine Mountain proper). Another bed of serpentine, with some impure chrome ore mixed through it, occurs in Gee's selection, about 50 chains due east of the above.

"Immediately east of the serpentine there is a bed of impure brownish limestone. This crops out in Hughes's selections Nos. 306 and 308; in Thompson's selection No. 309; and Hill's selection No. 160A. Further south, in Donnell's and Pennell's selections, the cherty magnesian limestone already

* Annual Report of the Under Secretary for Mines for 1894.

referred to occurs. This limestone, I am informed, contains too much magnesia to be of service in the manufacture of cement. Outcrops of this limestone occur in selections Nos. 267, 268, 275, 286, 300, and 301.

"East of this limestone there is a bed of quartzite stained with oxide of iron; in some places there is such a large percentage of oxide of iron that it becomes a siliceous hæmatite. The outcrop of this bed is 16 chains across in places.

"A drive was put in close to Mr. Russell's house, on selection 312. . . . The drive was about 25 feet in length to the face. The stone was assayed, but found to contain too much silica to be of any use for the manufacture of iron: in fact, the greater part of it was simply an iron-stained quartzite. Some holes have since been sunk by Mr. Russell to the east of Mr. Lloyd Owen's workings, in which he came upon stone with a high percentage of iron in it (a siliceous hæmatite). This richer stone appears to be running in layers parallel to the strike of the beds.

"The same bed of quartzite, with occasionally fair ironstone, can be traced northerly through Brice's selection No. 384, and on, I am informed, across the Brisbane River, and in a southerly direction away to Gee's selection No. 273, and Pennell's selection No. 269.

"Leaving in abeyance altogether the question whether it would be possible to manufacture iron at a price that could compete with the imported metal, there is not stone here suitable for its manufacture in anything like sufficient quantity.

"Another bed of this iron-stained quartzite occurs further to the east, in Scott's selection No. 377."

Prospects.—It is evident from the above that attention has thus far been directed solely to the "quartzite" outcrops, as probably the caps of lodes. While it seems from analogy with the Lake Superior deposits possible that these outcrops will pass into iron ore at a depth, it is also very probable that there are large deposits of ore in the hollows between the outcrops.

In order to test this assumption, rough samples of the surface soil were taken from various localities, but the results of assay were very disappointing.

The following seem to be some of the most likely places for soft ores:— The hollow on the western part of portion 482; the "neck" on the west of Sherlock's Summit; the centre of portion 273; the western side of portions 290, 291, and 292; the western parts of portions 322, 323; portion 319 (?); and centre of portion 379. It may be taken that the average width of these areas will be five chains, and the length from five to 20 chains or more. No definite calculations can be made till the ground has been thoroughly tested, preferably by means of diamond drills.

Owing to the vicinity of the Ipswich coal measures, this locality is all the more worthy of prospecting for iron ores. (What little ore has been found consists of hæmatite.) The Esk Railway passes within a mile of the deposits, and splendid grades could be found for a connecting line, when the total distance from Ipswich would be about seven and a-half miles.

Were steel works erected at Pine Mountain, manganese ore might be brought in small quantities from Kholo, but if that did not suffice, it could be shipped to Brisbane, taken up the river to Ipswich in punts, and then railed to the works.

Pure limstone is the only requisite not found in quantity in the district. Limestone for use in Brisbane has for some years been obtained from the

Duke Islands (between Rockhampton and Mackay), and it might be necessary to bring the flux from there.

Geology.—Pine Mountain is really almost an island in the Ipswich coal measures. No fossils have yet been obtained to give any clue to the age of the rocks. It can only be said that they are much older than the Ipswich coal measures. The youngest rock in the district is the basalt which occurs in patches on all sides of Ipswich. It seems probable that this rock issued from volcanoes or fissures to the south of Ipswich. That now covering an area of two and a-half square miles between Muirlea Station and Pine Mountain seems to have flowed along the western side of the mountain, where fragments only can now be found (portion 293).

The strike of the strata can only be assumed from the outcrops of the quartzite, jasperoid, and serpentine, varying from west-north-west to north-north-west. The dip is nowhere distinguishable except on the river bank in portion 482, where, in one place, it is 40 degrees to the north. It would seem that the strata east of an axis running north-north-east through portion 482, strike nearer east and west (say east-south-east) than the remainder, which strike north-north-west. A reason for the occurrence of the ore deposits is therefore given in that the strata at the bend were shattered, and possibly opened along the bedding, giving circulating waters free passage.

The most western bed exposed, for a distance of a few yards up to 20 chains, consists of a very ferruginous rock, with a skeleton of silica and patches of a green magnesian silicate and veins of opaline chalcedony—probably highly-altered serpentinous rock, as assumed by Mr. Rands. Next to this rock, and sometimes included in it, comes schistose unaltered serpentine, with an average width of a few chains only, but in places up to ten chains.

No extensive beds of limestones were seen, the rock only occurring in small lenses in the slates and jasperoids, the latter rock being probably due to the replacement by silica and iron.

The white magnesian limestone referred to by Mr. Rands is, in my opinion, a secondary deposit, due to the decomposition and leaching out of a former covering of basalt.

The jaseproids are dense, red, flinty rocks, owing their origin chiefly to secondary changes in the original slate or limestone. Partial or complete solution of the original constituents has taken place, and iron and silica have been precipitated in their place. Such a rock is of universal occurrence throughout Queensland in connection with iron and manganese deposits in the older rocks. It is not confined to Queensland being found also with the Lake Superior, United States of America (taconite) deposits, in Cuba, and in Brazil. In many of the Lake Superior deposits the taconite forms a capping over the whole or part of the ore.

The belt of iron-bearing rocks forming Pine Mountain is found to continue north-north-westwards beyond the Brisbane River into the parish of Sahl, where there are most promising indications, on which no work of any kind has been done.

Chromite.—This hitherto undescribed outcrop, on portion 29, Sahl, is 11 miles north-north-west of Ipswich, on the closed part of the old main Brisbane stock route, two chains from the western side of the portion.

The fragments forming the outcrop, and varying from pebbles up to masses of several tons wéight, cover an area up to five yards across, extending in a

south-south-easterly direction for a distance of two chains. It can reasonably be assumed that there are at least 50 tons of ore on the surface. Ore containing 50 per cent. chromic oxide is worth £5 3s. per ton (April, 1904). The following is the result of analysis (Government Analyst):—

Iron	13	per cent.
Chromium	28	,,

(equivalent to 33.5 per cent. chromic oxide).

The soil here is dark-brown, and at the time of my visit carried thick grass, which rendered geological work very difficult. The only rock-fragments to be found consisted of quartzite, there being no sign of serpentine. Chromite is also found as scattered fragments in the serpentine area between the Pine Mountain school and the mountain itself. These were referred to by Mr. Rands in his report.*

2. NORTH IPSWICH.

Locality.—The property of the Ipswich Coal and Coke Company, portions 178, 179, 184, 123, 126, &c., Chuwar, is at the head of Bundanba Creek, three to four miles north of Ipswich.

Extent.—Ten outcrops of clay ironstone were seen within two miles on a north-east line. As there are a number of faults, the actual number of beds may be less. The tip from Gallen's shaft on portion 123, contains a quantity of ore—a band three feet thick is said to be at a depth of 40 feet.

Clay ironstone is said to form the floor of the Binley (Glencoe) coal seam. The seams are reported to extend for miles. That on 179 and 178 can be followed for a distance of a quarter of a mile. This has a thickness of two feet six inches, and makes a stronger outcrop than the others. The outcrop consists chiefly of limonite.

In calculating the probable quantity available a band of ore (of specific gravity = 4) one foot thick may be taken to contain 12,000 tons per acre.

The proximity of coal is important. A large seam with bands runs through the centre of the property, only a few chains from the largest of the clay iron outcrops. Coal has been worked to some extent in the Glencoe and Boxwood Collieries.

These bands would be worked in conjunction with the coal, and would be roasted and smelted on the ground.

Upper Kholo Bridge, on Brisbane River. Samples of limonite have been brought in from this locality, but the occurrence has not yet been inspected.

In connection with the above the occurrence of clay ironstone at Slack's Creek, 16 miles south-east of Brisbane, and also on the Burrum Coal Field, should be mentioned.

3. PARISH OF DUNDAS.

Locality.—Portion 140, Dixon (and 33, Dundas), 13 miles east of Esk. Portion 140 is in broken country at the head of Middle Creek, but portion 33 is in comparatively gentle country. It is believed that the road down Middle Creek

* *Op. cit.*

to Bellevue Railway Station is very gentle. The distance is about 18 miles. Esk is nearer, but part of the country to be traversed in that direction is rather broken.

Fig.7.

Extent.—The main deposit is 18 inches thick, extending for only a few yards, ten at most, with well-defined walls, but sometimes including country rock. Fragments of ore are found on the hill above, on the north-east, covering an area 70 by 100 yards, and down the hillside on the south-west to Middle Creek. They have probably been shed from small lenticular bunches.

Ore.—The ore is massive crystalline hæmatite of great purity. It is strongly magnetic.

Country.—Clay slate, striking north-west and dipping north-east, and dykes of syenite. A large outcrop of granitic syenite occurs on portion 90, about one mile north-west from the iron ore. The ore probably owes its origin to a continuation of this mass under portion 190. The deposit is mentioned because an exaggerated idea of its size has been formed by many. There probably are other deposits in the locality, but no prospecting has been done for iron.

4. PARISH OF DUGANDAN.

Locality.—Parish of Dugandan, pre-emptive purchase 1. On the chain-road, about three-quarters of a mile north of the Dugandan Bridge over Teviot Brook, 2½ miles east-north-east of Boonah, which is 59 miles distant from Brisbane by rail.

Extent.—Two outcrops of clay ironstone (each six inches to a foot thick, weathering red with cracks filled with calcite), dipping at an angle of 45 degrees north-west, are separated by about 40 feet of shaly sandstone containing petrified trees preserved in limonite. A dark band (probably a coal seam) under sandstone occurs about six feet above the clay ironstone. Numerous (half a dozen) beds besides these are to be seen on the main northern road from Dugandan Railway Station, a mile to the west of the above-mentioned outcrops. They do not extend to the east because of the intrusion of the trachyte (?) mass forming Mount Dugandan.

A sample from the large seam on pre-emptive purchase 1 yields (Government Analyst): —

Iron	... ...	45.36 per cent.
Silica	... ...	12.4 „
Phosphorus	... ...	0.234 „
Sulphur	... ...	Nil.
Carbon dioxide	...	4.4 „

Some little work would have to be done on these deposits to show whether they are thick enough to be worked. It is, however, highly improbable that such ore could be worked even if, as people in the district report, almost every well sunk has passed through one or more coal seams of medium thickness—two or three feet.

5. PARISH OF COOCHIN.

Various outcrops of clay ironstone are seen on the road running south from Dugandan to Coochin Head Station.

(*a*) Boulders one mile north of the Wallace Creek Crossing.

(*b*) Outcrop on the road between portions 104 and 46N. There are also signs of two seams of coal within a quarter of a mile to the north-west.

B—Limestones.

1. Pine Mountain.

The only bedded limestones known in the Ipswich district are the small deposits near Pine Mountain, but magnesites, passing into dolomite, and even into limestone, occur as secondary products, due to the decomposition and leaching out of the basalt caps found at numerous places.

2. Ipswich.

The limestone on Limestone Hill, which was formerly used locally for making cement, was proved by Mr. Maitland, a former Assistant Government Geologist, to be the cap of an igneous dyke.*. The quantity available for any purpose is not large.

C—Manganese Ore Deposits.

1. PARISH OF KHOLO.

Introduction.

The deposits visited are in the southern part of the parish of Kholo, from six to nine miles north of Ipswich, and all within three miles of the Brisbane River. Besides those shown on the map, others are reported to be in the broken country in the far north of the parish, and still others occur near the Moggil parish boundary, a few miles to the east.

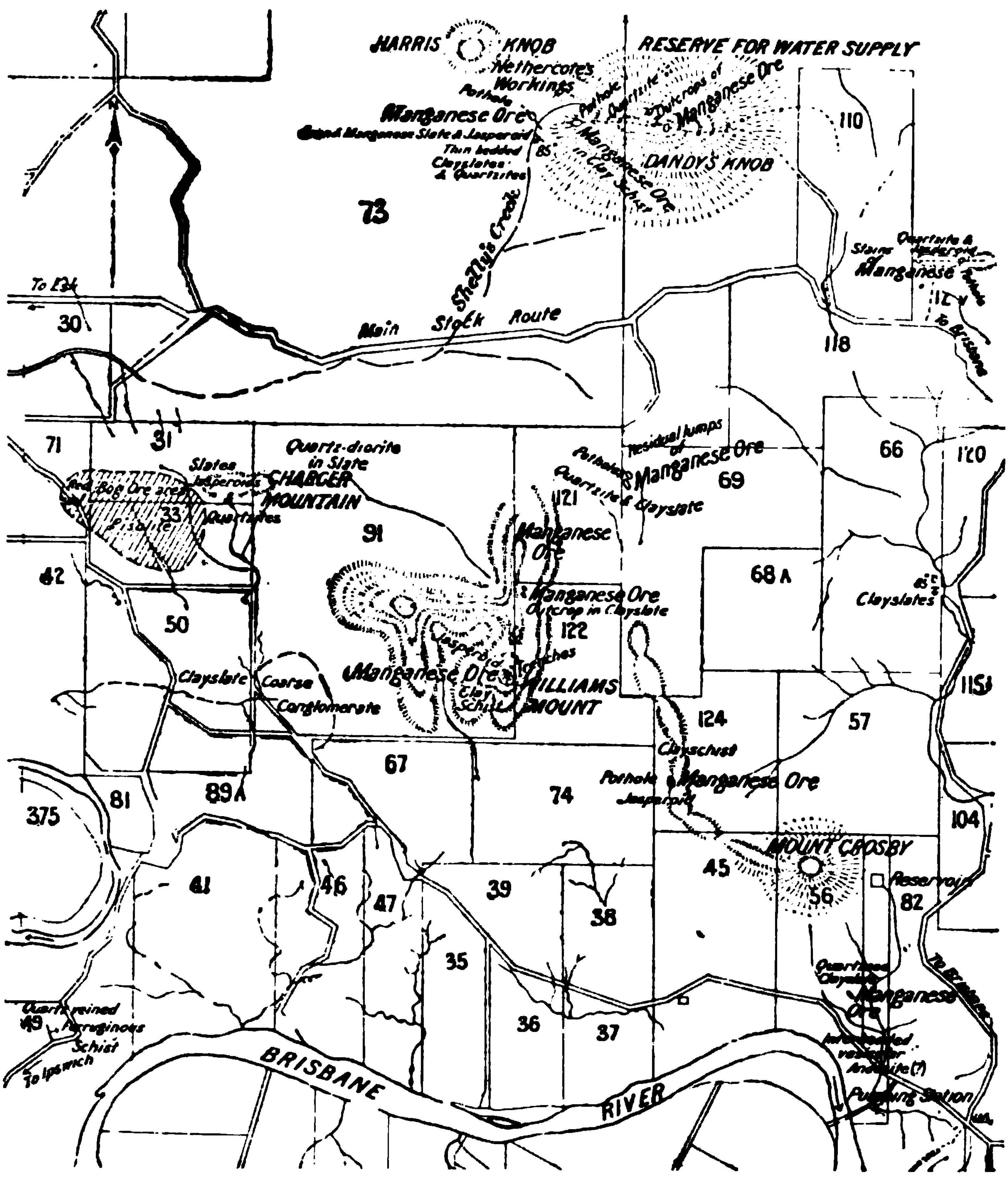
Serious mining operations have been undertaken at only one place—viz., Dandy's Knob, on the reserve for water supply, but trenches and potholes have

* Ann. Prog. Rep. of William H. Rands, Assistant Government Geologist, for the year 1894.

MANGANESE ORE DEPOSITS,

PARISH OF KHOLO.

Scale: ½-mile to an inch.



L. C. Ball.

been opened on portions 91, 56, 24, 69, 73, and 12v. The manganese occurs in bunches generally containing only a few tons of ore, and operations have in these cases been suspended as soon as the bunches cut out. Portions 56, 69, 122, and 91 have been leased by the owner for manganese mining for a term of twenty years for a royalty of 1s. 6d. per ton raised.

The distribution of the outcrops over an area of six square miles gives promise of permanency. Larger deposits may yet be found, and the comparative purity of the ore is some inducement to prospect. At present, however, nothing is being done in the district. The value of the occurrences lies chiefly in their proximity to the Ipswich coal and iron deposits.

The Kholo manganese ore, as a whole, is freer from clay than that at Gladstone, and when pure, a much larger proportion of it is soft, most of the harder material being only partly replaced slate. The deposits occur in at least four distinct zones or horizons. The country rocks (clay slate and schist, quartzite and red jasperoid), are very similar in general characteristics to those at Gladstone, though more thinly laminated in the Kholo district. Their age has not yet been determined (though shown on the State map as Gympie, Permo-Carboniferous).

Dandy's Knob.

Locality.—This mountain lies just outside the eastern boundary of portion 73, half a mile north of the main stock route, and at the junction of the ranges separating the waters of Cabbage-tree, Shelly, and Cameron's Creeks. It rises some 300 feet above the stock route, and 500 feet above the river.

Workings.—Manganese-bearing clay slates and jasperoids have been trenched for a distance of two chains. The main opening in clay slate and jasperoid (dipping 70 degrees north a few degrees east), from which a small bunch of ore has been removed, is ten chains east of portion 73. A shaft has been sunk 80 feet in clay schist 20 feet north of this. At the time of my visit it was open only to the 30-feet level, where there is a crosscut to the lode ten feet in length. This appears to have met a bunch of ore six feet long and up to a foot in thickness. Practically all the ore was removed, so that no idea can be formed as to its quality; the adjacent country is quartzite.

It might have been worth while crosscutting 15 or 20 feet further to reach the manganese-bearing stratum exposed in the hole south of the main open cut. The stratum consists of three feet of clay slate and jasperoid, partly replaced, and veined with manganese dioxide, and is very likely to improve in depth.

A mistake was made in sinking the shaft away from the lode, because of the bunchy occurrence of the ore. Had the shaft been sunk on the lode, any small bunches of ore struck would have helped pay expenses, and much more prospecting could have been done.

Between 70 and 100 tons are reported to have been shipped from this place, but no records are available.

Portion 91.

Williams' Hill, on the eastern side of freehold portion 91, about 15 chains from the southern boundary, rises 300 feet above the Brisbane River.

An outcrop of jasperoid clay slate, partly replaced by manganese ore, and varying in width from two to four feet, can be traced in a north-westerly direction across the hilltop for a distance of a chain from the eastern boundary. Two small bunches of ore, ten yards apart, have been opened, yielding a total

of only two or three tons of marketable ore. This ore assays (Government Analyst):—

Iron	... ...	0.56 per cent.
Silica	... ...	17.7 „
Manganese	... ...	42.7* „
Phosphorus	... ...	0.13 „
Sulphur	... ...	Nil.

The immediate country is clay schist, except at the northern end, where reddish jasperoid forms the footwall.

Portion 56.

There is on this freehold a small outcrop on the end of a spur, five chains north of the river road and 25 chains north-north-west of the Mount Crosby Pumping Station. A trench ten feet long and six feet wide, has been opened to a depth of five feet on a body of ore which appears to dip 45 degrees to the south-west. The ore has a slaty glassy appearance, and altogether about ten tons have been obtained. It assays (Government Analyst):—

Iron	... ...	0.67 per cent.
Silica	... ...	27.6 „
Manganese	... ...	42.4 „

The country rock is quartzose clay slate.

Portion 124.

On the western slope of a razorback running from Mount Crosby along the western side of this freehold is an outcrop of manganese ore, 300 feet above the river. The surface soil has been scratched away, but really no work has been done, and little can be seen of the deposit. The ore body appears to be two feet thick, and to strike north-west. South of it is jasperoid, and north is clay schist. It is worth testing.

Portion 69.

Two patches of about a ton each of residual blocks of good ore have been found in the north-western corner of this freehold. The country is quartzite and clay slate, and beyond the blocks mentioned there is no sign of ore. Further prospecting in the locality would, however, no doubt lead to additional discoveries.

Portion 122.

In the north-western corner of this freehold similar lumps of good ore are found, but amount to only a few hundredweight. They indicate the general manganiferous nature of the locality.

Portion 73.

There are two outcrops on this freehold. The first, on the line of the Dandy's Knob lode, is about 20 chains west of the main shaft there, and consists of two to three feet of clayey schist and manganese ore. A shaft was, without result, sunk ten feet on this, in the reasonable hope that there might be a bunch of ore beneath, the surface material being quite unmarketable.

* Equivalent to Manganese dioxide .. 64·8 per cent.

The second outcrop is five chains further west, and is only about 150 feet above the river. A trench was opened in four feet of red clay soil, with residual lumps of siliceous ore, on quartzite partly replaced by and containing bunches up to three feet thick, of poor slaty ore. There is very little marketable ore, but it may, as elsewhere improve at a depth.

In the creek below the last deposit is a ten-feet band of ferruginous and manganiferous slate which, owing to the proximity of quartzite and jasperoid, is worth following and prospecting for bunches of manganese ore. The occurrence of a permanent spring here gives further promise of there being ore deposits on this line.

Portion 12v.

Manganese-stained quartzite and jasperoid, five chains north of the main stock route, have been prospected at several points in portion 12v, but it seems to have been labour wasted.

Portions 31, 32, and 71.

Included partly within each of these freeholds is an area 18 chains in length and 12 chains in greatest width, consisting of flat red soil country, which is believed to be underlaid by bog iron-manganese ore. The only place where the underlying rock can be actually seen is in a small cañon-like creek running south, through portion 32, from the boundary of portion 31. Here it is coarsely pisolitic bog ore. Near its head the creek has exposed five feet of ore, in which, judging from its appearance, manganese is in excess of the other constituents. Iron and alumina gradually increase for a few chains towards the south, but about ten chains down the manganese again predominates. The pisolitic structure is much more pronounced where the manganese is most plentiful, the rock having a brecciated appearance when it is absent. Where the creek passes out of the pisolite on to the clay slates it has cut down into the former to a depth of 20 feet. A rough sample from the whole length of the creek contained (Government Analyst):—

Iron	11.58	per cent.
Aluminium	5.25	,,
Manganese	7.17	,,

Boring would be necessary before any exact or even approximate determination of the amount of ore present could be made; but taking the average as one-third the greatest thickness (say, six feet), and the area as 15 acres, there will be, roughly, 145,000 cubic yards, equal to 360,000 tons of ore in the deposit.

With regard to the origin of the above, there must formerly have been covering the area a swamp which received part of the drainage from the Charger Mountain ridge on the north. This ridge is built up of quartzites, slates, and jasperoids, with evident traces of manganese ore. The iron and manganese would be dissolved as carbonates, and precipitated in the bog as oxides.

According to its composition the ore will be a wad (manganese dioxide), limonite (hydrated iron sesquioxide), or beauxite (hydrated alumina). The first, if containing more than 40 per cent. manganese, would be of value in steel-making, the second as an iron ore, and the third for the manufacture of aluminium, alums, and as a refractory material for furnaces.

V.—DARLING DOWNS DISTRICT.

A—Iron Ore Deposits.

1. PITTSWORTH.

Deposits in Basalt Area.

PORTION 1847, RIVERSTON.

The ore deposits are in the south-eastern corner of the portion, three miles north-east of the Pittsworth Railway Station. (*See* Locality Plan 27.)

The outcrops, consisting of scattered blocks of variously hydrated oxide of iron, occur on the crests and slopes of low basaltic ridges. Only two or three potholes have been opened on the deposits, and, owing to their dilapidated condition, little can now be learnt from them.

(*a*) The first "blow" is on the southern side of the portion, about ten chains from the western boundary. It consists chiefly of boulders of massive brown limonite ($Fe_2O_3.1\frac{1}{2}H_2O$—hydrated oxide of iron), sometimes showing a structure resembling that of decomposing basalt, with a little yellow gothite ($Fe_2O_3.H_2O$). The area covered is about a chain in diameter, and assuming a thickness of one foot, it contains less than 100 tons of ore. Pebbles of ore also occur scattered over the surface for several chains to the west. The deposit is surrounded by basalt, and probably rests on the same rock.

(*b*) The next outcrop is five chains to the east. It is only five yards in diameter, and consists in greater part of decomposed basalt. Unweathered basalt lies all round it.

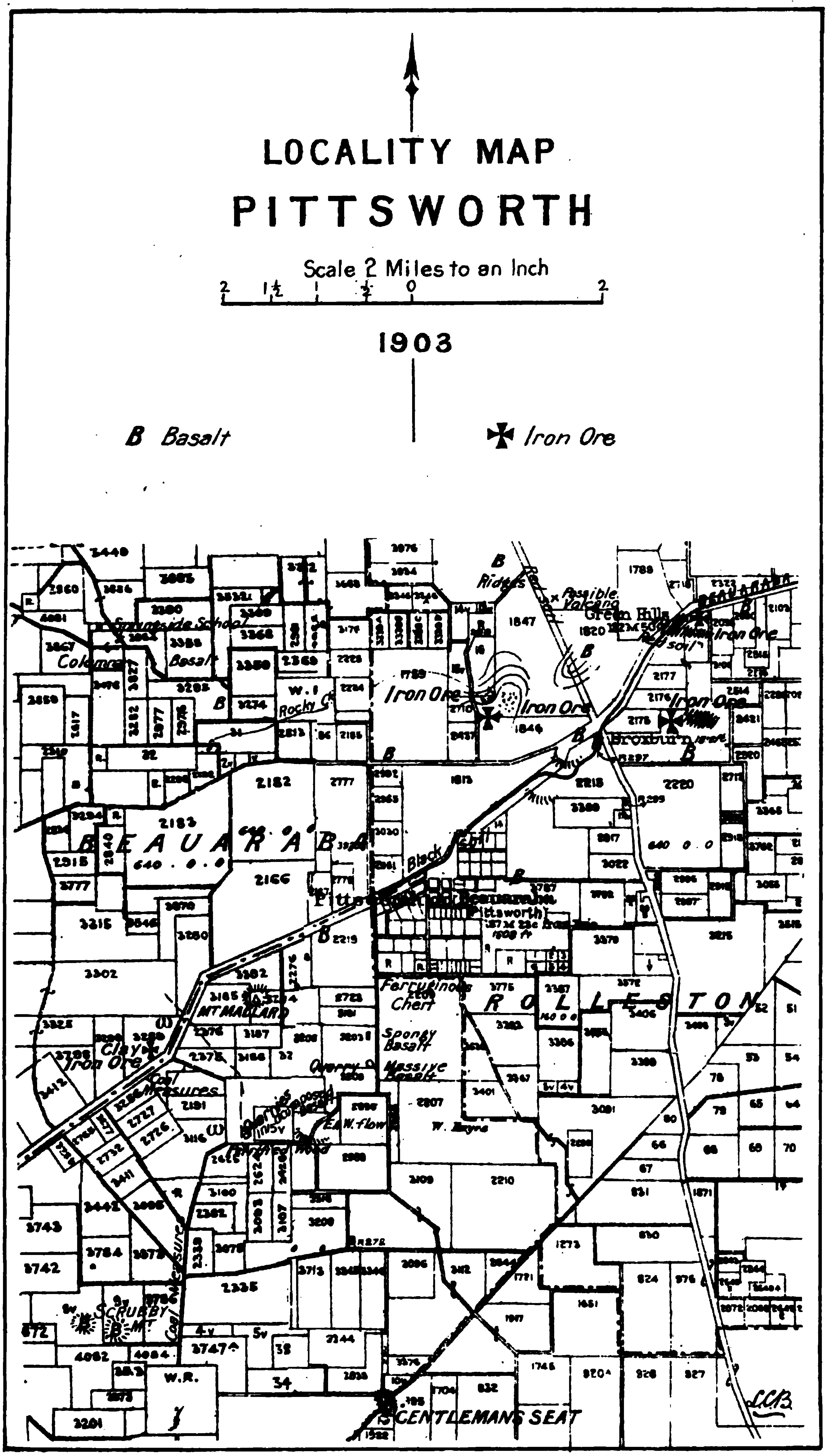
(*c*) The third outcrop is 20 chains from the western boundary. It is five chains in length in a north and south direction, and its width increases from a quarter of a chain at the hilltop on the south to five chains on the slope to the north, the total difference in elevation being about 50 feet.

The ore consists chiefly of light-brown gothite, with a smaller amount of dark-brown limonite and reddish-brown turgite ($Fe_2O_3.\frac{1}{2}H_2O$), the conchoidally weathering limonite occurring chiefly towards the western side of the outcrop, and abutting directly against undecomposed basalt.

Near the hilltop a shaft was sunk to a depth of 13 feet, but it is now filled in below eight feet. It proves that the iron ore at that point forms a capping from one to three feet thick, and that it decreases in quality with distance from the surface. Below the iron ore is soapy kaolin (decomposed basalt or volcanic mud?) variously stained with iron oxides.

The spur running north-east from the pothole is capped for five chains with turgite and limonite (one to three feet thick, in a trench near the centre), and in the lower portion the ore spreads out over a width of four chains. The thickness may in places be ten or 20 feet, but it is more probably generally less than three feet. The solid, reddish, earthy ore along the ridgetop gradually becomes more and more hydrated down the flanks.

GEOLOGICAL SURVEY OF QUEENSLAND MAP 27



Taking the average thickness as two feet (no more than which has been proved), the amount of ore present is about 10,000 tons, and the general sample from the whole of the outcrop yields (Government Analyst):—

Iron	49.9	per cent.
Titanium	Nil	
Silica and insoluble...	10.1	„
Phosphorus	0.34	„
Sulphur	trace	

The basalt above and to the south-west of the pothole seems to be columnar, and occurs in small ridges, which have a striking resemblance to lava flows. Small pieces of magnetite are found scattered over this country.

(*d*) A fourth outcrop lies across the gully to the north-north-west of the above. A pothole opened ten chains north of the south-eastern corner of 16v is three feet deep, and still in solid limonite. The ore is less pure than that to the south; it contains a larger amount of both water and clay, and, besides, the outcrop is not so well defined. North of the pothole scattered pebbles are found for a quarter of a mile.

(*e*) Solid earthy mammilated and concretionary turgite and limonite outcrop on the boundary of 1847 and 16v, three chains east of the road on the western side of the portions, with basalt on both sides and above or to the south. The outcrop is between three and four chains long, and is one and a-half chains wide. Assuming a thickness of one foot, the amount of ore present may be taken as 3,000 tons.

Portion 2110, Rolleston.

Lumps and pebbles of earthy turgite and limonite occur in a belt of red soil, which crosses portion 2110, Rolleston, and the Pittsworth Railway Line, a few chains west of Green Hills Railway Station. It is said that solid ore can be reached at a depth of two feet anywhere on the ridge. At one place on the road, a quarter of a mile from the railway line, blocks of ore lie scattered over an area five chains across. A large specimen of the ore was obtained, and is now on exhibition in the Geological Survey Museum.

Portion 2188, Rolleston.

On portion 2188, ten chains to the south-west of portion 2514, and one mile south-south-east of the Green Hills Railway Station, is another outcrop, five chains in diameter, with a narrow tongue running south for several chains. Large blocks of ore—gothite, limonite, and turgite (in small amount)—lie partly buried in the red soil. The limonite is the hardest, and the others seem to have been derived from it. Its fracture is often conchoidal, and its appearance is sometimes almost glassy, but the softer parts are minutely honeycombed. On the whole the ore here seems to be less altered than on portion 1847.

No data can be obtained as to the thickness of the deposit, but the amount of ore may be taken as 1,000 tons for each foot in depth. The sample from the whole surface contains (Government Analyst):—

Iron	52.3	per cent.
Titanium	Nil.	
Silica and insoluble...	8.9	„
Phosphorus	0.2	„
Sulphur	trace	

Undecomposed basalt outcrops on the north and north-east, and kaolinised basalt forms dark soil on the other side of the deposit.

Origin of the Ores.

Mr. Jaquet, in his memoir on the iron ores of New South Wales,* refers to ore similar to the above, but light-brown in colour and vesicular in texture, as "basaltic iron ore." He believes that they have been derived by weathering from basalt, and gives the following analyses:—

	Limonite.		Basalt.
Fe_2O_3 ...	43.16 per cent.	(metallic iron 30.21 per cent.)	3.86 per cent.
SiO_2 ...	33.04 „	... ...	41.15 „
P_2O_5 ..	0.54 „	... ..	0.27 „

The ore—always low in iron, and high in silica and other impurities—invariably rests on basalt, generally in swampy places, and forms a crust from a few inches to several feet thick, sometimes over several acres. Beneath the ore lie variously-coloured clays with scattered lumps of ore.

The undecomposed state of the basalt surrounding the Pittsworth iron ores, and the fact that the deposits are sometimes on ridgetops, are rather against the application of the theory here. The evidence on the field certainly pointed to the ore having been derived from a volcanic rock, but more probably a volcanic mud than a lava, flows of the former having quite possibly taken place at the end of the volcanic period.

Deposits in Coal Measures.

Beds of clay ironstone (impure carbonate and hydrated oxide of iron) occur in the coal measures west and south-west of Pittsworth.

An outcrop can be seen on the main Yandilla road (between portions 4084 and 3786, North Branch), three miles west-south-west of the railway terminus. The bed is about 12 inches thick, dips apparently 70 degrees to the west-north-west, and is included in calcareous sandstone.

Similar calcareous sandstone and clay ironstone, together with wood petrified by turgite and calcite, ocurs on the branch road leading up to Scrubby Mountain, five and a-half miles south-south-west of the railway terminus, but there is no actual solid outcrop.

These deposits may not be of any account in themselves, but they are most important in showing the existence of clay iron ore in the coal measures. Coal seams have been proved in numerous wells in various parts of the district, and it may prove possible in the future to work the coal and iron ore at the same time. It will thus be necessary, when boring operations for coal are undertaken, to keep an account of all iron ores passed through, and the hope may be entertained that much more important beds than those now known will be found.

Limestone flux seems to be the only thing wanting in the district for the reduction of the ore, and this will have to be procured, even though a certain proportion of the ore proves to be self-fluxing.

Conclusion.

Freight.—Pittsworth is 137 miles distant by rail from Brisbane, the nearest seaport. It is doubtful whether any ore for iron making could be profitably sent such a distance with our present freights (11s. 8d. per ton); but there is no doubt that ore of the quality found at Pittsworth could not bear the expense. Therefore, the only alternative would be to smelt the ore in the locality, and for this both fuel and flux are required.

* "Iron Ores of New South Wales." By J. B. Jaquet, A.R.S.M., F.G.S., Geological Surveyor. Sydney: By Auth., 1901.

Flux.—The nearest limestone on the railway is at Silverwood, 73 miles distant, and the freight would thus be a very heavy item.

Fuel.—There would probably be no difficulty in obtaining supplies of coking coal by sinking even in the immediate vicinity of the ore deposits, as thin seams of coal have been proved in several wells within a few miles distance, and the coal measures are known to pass under the basalt. I have not seen any of the seams, but specimens of highly gaseous coal were obtained from the mullock tip of the Government well, four miles south-west of the Pittsworth terminus. This coked only very slightly, but that may be due to long exposure. Several seams, one three feet thick, within a depth of 160 feet, are reported to have been cut in the Divisional Board well at St. Helens, eight miles west of Pittsworth, and another three-feet seam is said to have been struck at 40 feet depth in a well two miles west of the ore deposits. The beds are of the same age, and similar in character to those at Ipswich. It may, therefore, be taken that if sufficient ore could be found the fuel to smelt it would not be wanting.

Unfortunately, there seems to be no probability of the deposits in the basalt area extending for more than a few feet below the surface, and it is thus evident that only a few thousand tons of medium quality ore high in phosphorus can be depended on. The only likelihood, therefore, of the deposits ever being worked is in the event of the clay iron ores of the coal measures proving extensive. Then, should ironworks be established locally, all available ores will receive attention.

The Pittsworth ores, owing to their softness, vivid colouring, and comparative purity, should be of some use for the manufacture of pigments.

For the present the clay iron ores are not likely to be worked, because large quantities of far purer ore are found in much more convenient positions, but there is no doubt that at some time in the future they will be exploited.

2. WARWICK.

Only brief reference is here necessary to the occurrence of very similar limonite with laterite on Mount Sturt, in the Warwick district. The amount seen was inconsiderable, but no special search has yet been made there for the ore. The more ferruginous parts of the laterite here would probably be of value for the manufacture of pigments, the rock being soft, as a rule, vividly coloured, and in large quantities, within a few miles of the railway line.

3. TEXAS.

Reference to the occurrence of small bodies of limonite and magnetite with limestones will be found under the description of the Silver Spur Mine, in a separate report.*

B—Limestones.

1. SILVERWOOD.

Reference has already been made to the limestones near the Southern Railway Line, at Silverwood, nine miles south of Warwick. The deposits have not been inspected, but they are believed to be now being quarried, and the limestone is known to be of good quality.

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* Notes on Tin, Copper, and Silver Mining in the Stanthorpe District. By L.C.B. Bris.: By Auth., 1904. G.S.Q.P., No. 191.

C—Manganese Ore Deposits.

1. WARWICK.

(a) Parish of Rosenthal.

On portions 95v, 96v, and 3v, Rosenthal, six miles south-west of Warwick, are three lines of manganese outcrops, five chains apart. The country rock is slate and quartzite, which have been intruded within a few chains to the west by granite, and which a similar distance to the east are overlaid by sandstones and conglomerates, of Ipswich age.

The main outcrops are on portion 95v, and really consist of little more than slates and quartzites, stained and impregnated by psilomelane (dioxide) and rhodonite (silicate), though there is some reason for believing them to be on lines of fracture. The western deposit is two feet wide; the central is one foot wide on surface, but increases in quality and width with depth. The eastern at northernmost outcrop is eight feet wide, but consists in greater part only of partly replaced slate.

The deposits might receive attention were steel-works to be erected in the district, but there seems very little probability otherwise.

(b) Mount Gammie.

The deposit on this mountain, which lies 22 miles west by north of Warwick, as thus far opened up, has proved insignificant. It is mentioned because of the probability of an improvement taking place in depth, and a description will be found in a previous report.*

* Some Manganese Deposits in the Gin Gin, Degilbo, and Warwick Districts. By L. C. B. Bris.: By Auth., 1904. G.S.Q.P., No. 189.

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DEPARTMENT OF MINES.

Geological Survey of Queensland.

PUBLICATION No. 195.

MOONMERA:

(NEAR MOUNT MORGAN)

ITS MINERALS AND COPPER MINES, AND A STUDY OF ITS ROCK FORMATIONS.

WITH 2 MAPS AND 19 PLATES.

By B. DUNSTAN, F.G.S.,

ACTING GOVERNMENT GEOLOGIST.

BRISBANE:

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1904.

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(1140)

MOONMERA: ITS MINERALS AND COPPER MINES, AND A STUDY OF ITS ROCK FORMATIONS.

INTRODUCTION.

A FEW years ago a great deal of interest was taken in a discovery of copper-bearing rocks in the country immediately to the west of Moonmera, a station on the Mount Morgan-Rockhampton Railway, and since then prospecting developments have been in progress to determine their extent, character, and richness. This work has been carried on continuously and methodically, and, as well as outcrops of ore on the surface being exposed, other masses have been discovered whose existence was not previously suspected.

It was with the view of examining these copper deposits and their associated rocks, and also the Coal Measures overlying them on the higher country in the neighbourhood, that the recent geological survey was undertaken.

Moonmera is situated about four miles north from Mount Morgan, and about nine miles south from Kabra, the station from which the railway line branches off to Moonmera and Mount Morgan. Along the railway Moonmera is 20 miles from Rockhampton, but in a direct line, in a south-south-west direction, the distance is about 15 miles.

The country to the west and south-west of Moonmera is mountainous, and is a portion of the range which, to the north, begins near the Fitzroy River at Yaamba, extends southerly to Westwood, then irregularly to Mount Victoria, Mount Morgan, Moonmera, Moongan (where it is called the Razorback Range), and Mount Usher, and again southerly to the mountains at the head of Raglan Creek and Calliope River to the west of Gladstone.

The watercourses which rise at the Razorback Range take three principal directions. Four-Mile Creek, with other small rivulets to the east of Moonmera Range—a northerly spur of the Razorback Range at Moonmera—trends north-easterly and joins the Fitzroy River near Rockhampton, while Daisy Creek with its branches trends southerly and joins the Dee River to the east of Mount Morgan. The watercourses, westerly from Moonmera Range and north of the Razorback, run northerly and north-westerly to join different branches of Neerkol Creek, which, like the creeks on the east side of Moonmera Range, finds its way to the Fitzroy River in the vicinity of Rockhampton.

The topographical features around Moonmera are of a pronounced character, Moonmera Station being about 600 feet above sea-level, while Middle Peak, to the north-west on Moonmera Range, is 1,300 feet above sea-level, between the two places there being a rise of 700 feet in a distance of about a mile. South from Moonmera the rack-section of the railway to Mount Morgan rises a little less than 300 feet in about a mile, and in the gorges at the head of the Four-Mile Creek some of the surrounding ridges rise up to 500 feet in height in a distance less than half a mile.

The Moonmera Range is capped by rocks having a westerly inclination, and this, with other features, has produced rather steeply-inclined slopes on the western side, while the almost vertical joints in the same rocks have been the principal cause in the formation of the cliffs and the very steep slopes on the eastern side.

GEOLOGICAL FEATURES.

The rock formations of the country around Moonmera have not been examined in detail, but their general features have been observed, and a brief description will assist in comprehending the character of those in the immediate vicinity of Moonmera.

Granite and syenite occur in a large number of places between Moonmera and Table Mountain, in the direction of Kabra, and the formations here are composed exclusively of these rocks. Close to Mount Morgan a large area of the same rocks are exposed, and are probably connected with those at Moonmera beneath the younger rocks of the Razorback Range.

Another series of rocks, varying in age, but closely associated with one another, and presenting many interesting features in their mode of occurrence, are the diorites, felsites, and younger granites of the Razorback. When these rocks were being formed, those which contain the deposit of copper were probably brought into existence, although the evidence obtained from their examination tends to show that the copper-bearing minerals themselves were formed at a much later period.

At Moonmera there is a marked distinction between the granite, syenite, diorite, and felsite formations, as a whole, and the formations resting on them, the latter being stratified deposits of shales, sandstones, and tuffs of Mesozoic Age. A conspicuous geological feature to the west of Mount Morgan is the Marine strata belonging to the Permo-Carboniferous formation, and whilst there are no means of telling whether these old marine beds once existed around Moonmera, there is no doubt that a slow elevation of the Moonmera Range has taken place in past times. Prior to this elevation the beds might have extended much further east than where they are now found, and then to have been worn away before the more recent deposits now resting on the top of Moonmera Range came into existence.

The beds capping Moonmera Range are Lower Mesozoic Coal Measures, and are the edge, or portions of the edge, of the basin containing the Stanwell Beds, more fully developed to the north-west of Moonmera.

There are no well-defined formations in the district later than the Coal Measures, although "Desert Sandstone" was supposed to occur on some of the ranges; but at Moonmera the discovery was made of fossils which indicates the beds to be of the same age as the Stanwell Coal Measures.

During recent times no accumulation of rock-forming material in the neighbourhood of Moonmera has taken place, the work of nature consisting in breaking down the Coal Measures and older rocks, and carrying the *débris* away to form deposits elsewhere.

Granitic Rocks.

The main mass of granitic rocks is exposed to the north of Moonmera, while the smaller outcrops, which are of more recent age, occur at a higher altitude near the ranges to the south. In the railway cuttings, close to Moonmera, the granites and syenites are too much weathered for definite determination, but about a mile north-west from the station undecomposed granite is exposed on the spurs of Moonmera Range, and also in some of the shafts and tunnels in the copper mines.

The older granite is usually found to be medium-grained, but in some localities, more particularly near the head of Deep Creek at the base of Moonmera Range, it is of a coarse texture. The prevailing mica is biotite in the unweathered rock, but where exposed and decomposed muscovite predominates.

The granites of younger age are splendidly shown to the south of the station in the railway cuttings, where they penetrate masses of syenite and felsites, and dykes of diorite. They may be divided into two series by their mode of occurrence, the later formed being conspicuous by their disturbance of the earlier series.

Sketches of portions of the railway sections are shown on a number of plates accompanying this report. Plate 8 illustrates a section on the railway line marked "Cutting A" (*See* Map 1), where a vein of granite and aplite dislocates diorite and felsite masses. Plate 9 shows, on a larger scale, a portion of the same section where the granite is surrounded by a felsite, and also shows the selvage of felsite silicified where the contact takes place between this rock and the more recent granite. The aplite is not confined to any particular part of the mass although it predominates in the narrow portion of the vein.

Plate 10 (*a*), taken from "Cutting B," shows a small vein of (*c*) aplite a few inches thick in its widest part, filling the fault and dislocating a dyke of diorite. The vein tapers away at either end within a distance of a few feet. Plate 11 represents a section in "Cutting B," where a (*b*) granite older than that shown on Plates 8 and 9 penetrates diorite, and is, itself, disturbed by a more recent (*c*) aplite vein.

Plate 12, a section taken from railway cutting (C), illustrates a system of veins of one granite traversing a mass of another, the veins probably being the equivalent of the large mass of granite shown on Plate 11, while the massive rock would be the equivalent of the oldest *(a)* granite. The section is a very interesting one, and, with others in the same locality, would bear considerably more attention from a petrological point of view than can at present be bestowed on them.

On Plate 10 *(b)*, a section from "Cutting B" represents *(a)* syenite as the main rock mass, with *(b)* granite traversing it as veins a few inches thick. With the granite occurs a pegmatite, having vermiculite conspicuous as the mica constitutent. This mineral is found in all the granite and pegmatite veins.

Plate 13 (*a*) represents a section from a small cutting between "E" and "F," and shows a vein of coarse (*b*) granite in a partly kaolinized syenite. The syenite contains small nodular secretions of a fine-grained rock of apparently the same constituents as itself, but containing a greater percentage of the more basic minerals.

Plate 13 (*b*), taken from "Cutting F," shows two veins of (*b*) and (*c*) granite—marked Gr. 2 and Gr. 3 respectively—in a dyke of diorite. The diorite has been dislocated by the first (*b*) granite, and these together—the granite and the diorite—have been disturbed by the (*c*) granite along the line of fault. The (*b*) granite is a biotite granite, while the other (*c*) is a coarse vermiculite granite. (*See* description of Plate 13 *b*.)

Plate 14 illustrates a part of the "Cutting F." The (*c*) vermiculite granite here forms irregular veins in the diorite, and also traverses masses of felsite, apparently enveloped by the diorite. Plate 15 (*b*), from "Cutting G," shows a full-size sketch of a vein of (*b*) or (*c*) granite in a dyke of diorite. The vertical portion is a biotite granite, while the rock in the branch vein graduates into an aplite near the walls, with a vermiculite pegmatite in the centre.

Plate 16, "Cutting G," represents a rather complicated structure, the (*b*) or (*c*) granite being the youngest rock in the section. This granite is of later formation than the friction breccia shown in the section, a feature of some importance in view of a large copper-bearing breccia deposit of similar appearance being associated with felsites, quartz felsites, and the older granite in the Moonmera Copper Mines.

Plate 17 (*b*), from "Cutting G," shows a (*b*) granite vertically penetrating the diorite, both of these rocks being subsequently disturbed by veins consisting of (*c*) pegmatite and (*c*) aplite. Both the (*b*) and (*c*) series contain vermiculite. Plate 17 (*b*), from "Cutting G," shows a (*c*) aplite vein crossing diorite and felsite. The vein is wide in the diorite, and tapers away in the felsite without having even a joint as a continuation of the vein.

Plate 18, representing a section in "Cutting G," shows (*c*) aplite in an irregular vein, but, being of later formation than the diorite, the fault shown at the bottom of the sketch must have been formed *prior*

to the infilling of the fissure, and from which it may be concluded that an open fissure existed in the diorite, and subsequently was filled to form a vein of aplite.

At the Moonmera Copper Mines the granite occurs in numerous localities. The section on Plate 1, across the Moonmera Range, along the line A, B, C, D, on Map 2, shows a granite at the base of the Coal Measure conglomerates in the watercourse trending westerly from the Range. Plate 3 shows a section across the granite and felsite at No. 4 Tunnel; Plate 4, a section across the granite and other rocks at No. 7 Tunnel; and Plate 5, a section at No. 2 Shaft, where granitic and felsitic rocks occur in a breccia formation containing copper. The aplite is generally found to occur in both the granular and micropegmatite form, some of the latter in microscopic sections showing a beautifully-marked graphic structure.

Felsites.

The origin of the numerous felsitic masses exposed on the sides of the mountains at Moonmera is rather obscure, and no data have been obtained showing, beyond doubt, what their relations are to the granite with which they come in contact. Apparently some of the felsite masses are immense inclusions in the granite, as undoubtedly others of them are in the diorite. None of the railway sections show the two rocks in contact, and the surface outcrops observed in other places have not resulted in any satisfactory conclusion being arrived at.

To the west and south-west of Moonmera Station the felsite inclusions form prominences on the ridges, and are easily recognised from the decomposed granite and syenite in which they occur. In shape they are usually lenticular, and frequently extend to over 100 feet in length, although the inclusions in the diorite are often very small. (*See* Plate 14.)

In both the diorite and the granite the inclusions have the same "orientation," being persistently northerly, but with an inclination from the horizontal varying up to perhaps 45°. All their peculiarities, especially in their relations to the diorite, point to their being included in rock masses once subjected to a flowing movement.

In the railway cuttings to the south of Moonmera the relation of the felsites to the diorites is clearly defined, and numerous sections show the felsites to be older than the diorite. On Plate 8, the alternating bands of felsite and diorite do not positively prove the diorite to be of later formation than the felsite, but in the sections represented on Plates 10 (*a*), 14, and 15 (*a*) the evidence is unmistakable.

The felsites are intimately associated with the copper-bearing rocks, as shown in some of the workings of the Moonmera mines. Plates 1 and 2 represent what appears to be a "horse" of felsite included in a breccia, although this might be connected with the large

mass of felsitic rocks shown in another part of the same section, a plan of which is given on Map 2. Plates 3, 4, 5, and 6 also show felsite in contact with granite, but the relation of these rocks to one another has not been made clear.

A microscopic slice of the felsite from railway cutting (G) shown in section on Plate 15*a*, reveals phenocrysts of quartz with traces of biotite, some magnetite in the form of dust, and a greenish chloritic substance. Another rock slide from the felsite in cutting (B) shows blebs of quartz, biotite mica in traces, grains of magnetite, and needles of apatite disseminated throughout the section.

Diorite.

Without being able to bring any decided evidence to bear on the matter, the opinion is expressed that the older granites and syenites underlie the diorite. The ascent of the Razorback Range, *viâ* the rack-section of the railway between Moonmera and Moongan Stations, indicates that the granitic rocks are below the diorite in some of the cuttings, and it is only as veins of a younger granite that they are represented on the top of the range in the diorite and felsite. The railway cuttings show the relation of the diorites to the other rocks, and some of the sections reveal remarkable features.

On Plate 8 is represented a number of dykes penetrating the felsite. The centre one is narrow, being about two feet thick, while the one on the left of the section is very massive and irregular.

Plate 10 (*a*) represents a small dyke a few inches thick in felsite, the diorite and the felsite being subsequently disturbed by a thrust fault, the fault afterwards being filled with aplite.

Plate 14 shows the inclusion of a felsite in a mass of diorite, and Plate 15 (*a*) a diorite intrusion along an open fissure in the felsite. Evidently the faulting has taken place at right angles with the plane of section, and the upper portion (*a*) of the felsite has moved forward (at an angle to the plane of the paper) over the lower portion (*b*). These diorite intrusions have taken place along joints produced in the felsite inclusions in the larger diorite masses.

Plate 16 reveals other features. The felsites have been faulted, and the fissure which formed has been filled with brecciated fragments. Subsequently the diorite has been intruded along the same line of weakness, leaving the breccia as the footwall in part, with the felsite forming the hanging-wall.

A slice from a specimen taken from the railway cutting (G) on top of the range, under the microscope showed the rock to be fine-grained, to contain hornblende decomposed in part and stained with chloritic matter, and a plagioclase felspar much kaolinized. Another slice from the same place indicated the rock to be finer-grained, to contain idiomorphic plagioclase crystals much kaolinized, and more or less altered hornblende scattered through it.

BRECCIA.

The breccia formation is made up of fragments of granite, syenite, felsite, and other rocks, and is one of the principal copper-bearing deposits at the Moonmera Mines. Its greatest development is about a mile north-west of the railway station, and where exposed high upon the side of the mountains is very much altered and decomposed, and more or less calcareous, while low down in the ravines it is comparatively fresh, hard, compact, and siliceous.

It has an observed thickness or depth of about 300 feet, rests on granite in a depression evidently formed by surface denudation, and is covered by the sandstones forming the top of the ranges.

Where the sandstones further west have been weathered down and the older rocks below exposed, the breccia has not been found—granite occurring instead—from which it might be assumed, when taken in conjunction with other features bearing on the matter, that the breccia formation is deepest where it is covered by the sandstones at about Middle Peak, and that from this position it becomes shallower in all directions. Resting on the western outcrop of granite (*See* Map 2 and Plate 1) there is a massive conglomerate, which might have been derived from the deposit of breccia. It is composed of the same constituents as the breccia, and is situated at a lower altitude than the upper portion of this rock where exposed on the eastern side of the range. At the same time the breccia and conglomerate might be different portions of one deposit, the western part of which has been formed into a conglomerate by the attrition of the angular fragments in water.

Sections of the breccia are shown on Plates 1 and 2. Plate 1 illustrates the relation of the breccia to the felsites and to the sandstones with which it comes in contact, and is taken along the line A, B, C, D, on Map 2. Plate 2 is a part of the same section on a larger scale, and shows the smaller felsite portion apparently isolated from the main mass further east. From the inclination of the felsite formation at No. 8 Tunnel, where it is in contact with the breccia, and from the apparent isolation of the felsite mass further up the hill, it would appear that a "horse" of felsite has become detached from a larger mass and then enveloped in the breccia formation. (Map 2 shows a plan of this near the section line E F).

Plate 4 shows a section at the mouth of No. 7 Tunnel, where a breccia, consisting of fragments of quartzite in a matrix of felsite, is contained between granite walls, the rock apparently being intrusive. Breccia also occurs in No. 6 Tunnel, where the main formation seems to have been touched at a depth nearly 300 feet below the uppermost portion of the breccia at No. 1 Shaft.

Regarding the origin of the breccia, there is not much information available whereon to express an opinion, but if the breccia occurring in one of the railway cuttings be a guide (shown on Plate 16) then the large breccia formation has been produced by the crushing of felsites, syenites, granites, and micrograuites, and by the consolidation of the fragments into a compact mass. On the other hand, there is a greater probability of its being produced as volcanic ejectamenta, as there are other localities not many miles from Moonmera, in the direction of Westwood, where apparently similar breccia formations occur as volcanic necks; a careful examination of which might reveal further information bearing on the habit and origin of the Moonmera breccia.

Cupriferous Sandstones.

The copper-bearing sandstones occur at the base of the Mesozoic Coal Measures, and for the most part are very irregular and unstratified, and distinct from the overlying formation. They have been formed as detritus from the granite, felsite, and other quartz-bearing rocks, on the inclined surfaces of which they have been deposited. These cupriferous sandstones are 30 or 40 feet in thickness in some places north of the breccia formation, but other parts of the outcrop thin out into an irregular bed only a few feet thick, with granite, felsite, or breccia below, and coal-measure sandstones and tuffs above.

The variation in the thickness of the sandstones is accounted for by the varying angles of slope of the surfaces of the rocks on which they accumulated; and where the sandstones are absent, evidently the slopes of the older rocks have been too steep for the *débris* to rest on. In some places where the dip cannot be observed, it is difficult to distinguish the formation from the Coal-Measure sandstones above, as both partake of the same general appearance where they are in contact. High up on the sides of the cliffs to the west of the breccia formation, where No. 1 Shaft has been sunk, the cupriferous sandstones are absent—the granite rocks and the Coal-Measure sandstones being in contact—but south from the shaft they are present, and in that direction continue uninterruptedly for over half a mile.

The sections on Plates 1 and 2, taken along the line A, B, C, D, and that on Plate 6, on the line E F (*see* Map 2), show the relation of the cupriferous sandstones to the rocks above and below.

Regarding the origin of the copper in the sandstones, there is hardly any doubt but that the copper has been derived from the breccia and granitic rocks, and although the present position of the deposits of copper in the latter is generally lower than the sandstones, numerous features indicate that further east the breccia and granite were much higher at one time, and that the impregnation of the sandstones on their flanks by copper, leached out from the older and higher formations, would be a simple matter.

Mesozoic Coal Measures.

Sandstones and shales of a more or less ferruginous character, fine white thin-bedded tuffs, and a number of small inferior coal seams a few inches thick, constitute the Mesozoic Coal Measures resting on the cupriferous sandstone and breccia of the Moonmera Range. The Measures extend southerly to the Razorback Range, and then continue along the top of the ridges towards the west, occurring also in patches in the country to the north-west in the direction of Stanwell.

The Coal Measures do not occur easterly from Moonmera, although there are indications to show that at one time they must have extended some distance in this direction. Their contact with the formations of breccia, granite, felsite, and sandstones on the Moonmera Range show that their surfaces are rather steeply inclined to the west, and at an angle greater than that of the measures above them which dip in the same direction. As a thickness of 300 feet of the breccia is exposed, its top portion must have been extended much further to the east, where it would come in contact with the older rocks once existing there. The relation of the sandstones, &c., to the Stanwell Coal Measures was a subject of investigation, more particularly as they have been regarded as a "Desert Sandstone" formation.

The coal seams, such as they are, were considered to be of a higher horizon than the Stanwell Coal Seams, and with them to have no connection in any way. The present examination of the country to the west of the Moonmera Range, and also of the Range itself, shows that the rocks do not in any way differ from those of the Stanwell Measures. The sandstones and shales and inferior coal are similar to those at Stanwell, and the white tuffs are identical with those at Stewart's Creek to the north of Stanwell, and with those at Wycarbah near Mount Hay.

The palæontological data recently obtained also indicate their close connection, as the fossils occurring in white tuffs at the head of the gully above No. 6 Tunnel include *Alethopteris Australis* and *Thinnfeldia indica, v. Media*, the latter also being found in several places in the Stanwell Coal Measures. Bivalves occurring in the same tuffs were submitted for examination to Mr. Etheridge, the Curator of the Australian Museum of Sydney, who states that they appear to be the remains of one of the *Unionidæ* or some allied fresh-water mollusc, the distorted condition of the specimens, however, precluding a detailed description being made of them.

The Moonmera tuffs, shales, and sandstones appear to bear the same relation as the Stewart's Creek and Wycarbah tuffs do to the strata close to Stanwell, and may be considered a higher but conformable division of the Stanwell Measures. Further details will be available for consideration when the other portions of the Moonmera series come to be examined in the immediate vicinity of Mount Morgan.

Coal seams outcrop on the side of the Range to the south of South Peak, and the following section was observed by Mr. Rands, who inspected it in 1899:—*

	Ft.	In.
Coarse sandstone (thickness unknown)		
Black carbonaceous shale	2	9
Brown argillaceous sandstone	0	11
Black shales with streaks of coal	0	7
Brown shale	0	6
Black coaly shale	0	7
Brown sandy shale	0	3
Black coaly shale	0	11
Dark brown shale	0	8
Black carbonaceous shale	1	0
Total	8	2

An examination of the exposed section showed the coal to be of a dull appearance and very dirty. Some of the samples of the inferior coal yielded over 60 per cent. of ash, but small bands of the better quality gave about 30 per cent. of ash. The coal may be considered useless, not only from its quality, but also from the absence of seams of workable size. The rugged nature of the country over which the small isolated patches of the Coal Measures extend to the west of the Moonmera Range, would also make the working of a small and inferior coal seam impracticable.

Reference has already been made to the presence of conglomerates above the granite to the west of the Moonmera Range, and to the probabilty of their being derived from the breccia formation.

To the north-east of these massive conglomerates on the eastern side of the Range, another outcrop of a similar rock occurs. Very probably the two outcrops are connected with one another below the covering sandstones and tuffs, as they dip in about the same westerly direction, and are at about the same altitude. The section on Plate 1, taken along the line A, B, C, D, on Map 2, illustrates the position of the Coal Measures with regard to the copper-bearing sandstones, the breccia formation, and the granite and conglomerate on the west side of Moonmera Range. Plate 2 represents a portion of the same section on a larger scale, and shows more clearly the relation of the Coal Measures to the rocks in the vicinity of No. 1 Shaft. Plate 6 represents a section taken along the line E F, and Fig. (*a*), on Plate 7, another somewhat similar section along the line G H, also show the relation of the Coal Measures to the rocks below.

Recent Deposits.

Deposits of later age than the Coal Measures are very small in area, and are confined to the recent alluvial deposits in the beds of the creeks heading from the Razorback or Moonmera Ranges.

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* Progress Report of Geol. Surv. of Queensland. By Auth.: Bris., 1900. G.S.Q.R. No. 150.

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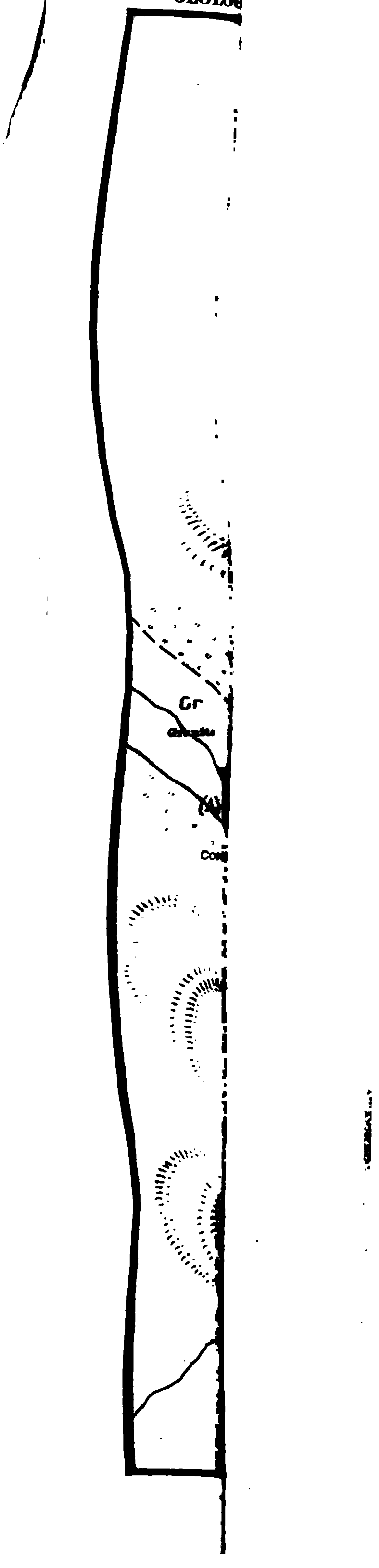


Gold has been found in some of the creeks, of which Four-Mile Creek and the creek to the east of Mount Scott have yielded several hundred ounces. The gold appears to have been derived from the numerous quartz leaders and veins which are known to be auriferous in the vicinity of the granite and diorite, especially about Mount Scott, where a large body of stone containing these veins is said to average a few pennyweights of gold to the ton.

Gold has been found in the gullies leading down from the gap between North Peak and Middle Peak (*see* Map 2), the source of which has not been discovered. Some of the old miners suppose the gold to come from the conglomerates at the base of the Coal Measures just above, but there are old alluvial workings in one of the gullies higher than the level of the conglomerates. The gold might have been shed from some of the Coal-Measure beds above the conglomerates, or possibly it has been derived from the older rocks, which, as previously stated, once existed further east at an altitude probably higher than the sandstones.

Small transparent red stones have been found in the creeks west of Mount Scott, and are supposed to be rubies, but none could be obtained to determine whether they were rubies or, more probably, zircons or garnets.

Geological Summary.

From the preceding remarks on the geological features of Moonmera, the following deductions are made on the sequence of the rocks of the railway cuttings and at the Moonmera mines:—

1. The oldest rocks in the district are the Felsites. They have been clearly proved to be older than the diorite, and the evidence generally shows that they are also older than the granite. They have not been observed to occur in any form other than as inclusions in younger rocks.
2. Granites and Syenites are the next series, a conspicuous feature being their disturbance by diorite intrusions.
3. The third series is the Breccia Formation, the individual rock-fragments of which are made up of felsites, granite, and syenite, with a conspicuous absence of *débris* from diorite.
4. Diorite is the next younger series, forming dykes in the granite, syenite, and felsites, and disturbing the friction-breccia deposits occupying a fissure in a felsite mass.
5. Following in order are the veins of Vermiculite Granite which have penetrated the diorite and other rocks.
6. A second series of veins of Vermiculite Granite, Pegmatite, Aplite, and Quartz, which have been formed in the older vermiculite granite and other rocks.
7. Faulting of the aplite, pegmatite, and other rocks.

8. **Accumulation of material to form the Mesozoic Coal Measures.**

9. **Formation of small bodies and veins of Dolomitic Limestone** in the decomposing diorites, and the accumulation of material to form deposits containing Alluvial Gold.

Most of these formations are illustrated in the diagrammatic section on Plate 19, and the changes they have undergone will directly bear on some stratigraphic and other features of the Mount Morgan rocks, which partake of the same general character. The felsites, granites, syenites, and diorites are all similar to those close to or on Mount Morgan, and the information obtained from their examination will be made use of when a study of the rocks of Mount Morgan is undertaken. Regarding the dynamics of the *dykes* of diorite and *veins* of granite, there is enough evidence in the sections exposed in the railway cuttings to show, conclusively, that the theory of intrusion will not account for the formation of the veins of granite in the diorite and other rocks.

As stated before, the granite is intimately connected with aplite and quartz in the same vein, the aplite gradually replacing the granite in some parts, and both changing imperceptibly into a vein of pure quartz. Without losing sight of the changes which might have taken place metasomatically, it is very evident that the granite veins have been produced under the same conditions as those of the quartz veins, and the petrological examination shows no perceptible difference in the character of the quartz where the veinstone is comprised exclusively of this mineral, or where it is associated with other minerals in the granite.

MINING DEVELOPMENTS.

Exploitation Work.

The principal mining work undertaken at Moonmera has been the exploitation of the copper-bearing deposits on the side of the Moonmera Range, although the alluvial gold deposits in the water-courses, the coal seams on the sides of the Range, the auriferous formations of Mount Scott, and the quartz veins in the diorite and granite, have each received some notice from prospectors.

The exploitation of the copper deposits began many years ago, but the results then were not considered satisfactory, and the operations were discontinued. The finding of other rich outcrops, however, resulted in attention being again directed to them, and ultimately a systematic development of the deposits took place.

Without going into the details of the time and order of developments, descriptions will be given of the formations in which copper has been found. They will be considered under the headings: (1) Deposits in the Breccia; (2) Deposits in the Granitic Rocks; and (3) Cupriferous Sandstones.

Deposits in the Breccia.

No. 5 Shaft.—This shaft is situated near the western boundary of No. 5 Mining Lease, and has been sunk to a depth of 64 feet in a breccia or sub-angular conglomerate containing fragments of felsitic and granitic rocks.

The breccia also contains blebs and patches of iron pyrites and copper pyrites, with films of molybdenite in the joints. The copper is found throughout the mass of the breccia, but the quantity of metal it contains is not more than one per cent., while most of the stone has less than this amount. Concentrates have been produced from a parcel of stone from this shaft, the yield of which is said to have given 11 grains of gold and 2½ dwts. of silver per ton, and 0.65 per cent. of copper, but there was no estimate obtainable showing the amount of stone required to produce the concentrates giving this return.

No. 1 Shaft and No. 1 Tunnel.—These workings are on No. 3 Lease, on the spur leading up to Middle Peak. The breccia formation here is of immense proportions, and must be over 300 feet in vertical measurement, this being the thickness observed between the outcrop high up at No. 1 Shaft and its lowest position in the ravines.

No. 1 Tunnel has been driven a distance of 65 feet to prospect what was thought to be a lode having a north and south trend, and to be a few feet in thickness, but the developments have indicated that the copper occurs in all directions in the breccia outside this supposed lode.

No. 1 Shaft has been sunk to a depth of 50 feet, on a very rich outcrop of carbonate and oxide ore contained in the breccia formation. Two short drives have been made at the bottom, one to the south, the other to the north, the latter showing oxide and native copper in places. Excavations have been made on the surface, between No. 1 Shaft and No. 1 Tunnel, and some very rich patches of ore containing carbonate and oxide have been exposed.

A sample was taken from 50 tons of stone on the surface, obtained from the north drive and from places in the shaft, and yielded 0.31 per cent. of copper and traces of gold and silver. This stone was thrown out without any attempt being made to separate the richer portions from the worthless stone, so that classification, if adopted, might increase the percentage considerably.

A parcel of 4½ tons of stone taken away from these workings was obtained from some rich "pockets" of ore in the breccia, and sent to a metallurgical works for treatment, and yielded four dwts. of gold and two ounces of silver per ton, and 28 per cent. of copper. A similar parcel sent to another works gave almost the same results. The occurrence of these rich patches of ore created the impression that a rich lode exists, but there is nothing to indicate that such is the case.

From No. 1 Tunnel about ten tons of ore have been separated from the other stone taken out, and a sample of this yielded 1.8 per cent. of copper and traces of gold and silver.

No. 2 Shaft.—This is about ten chains south of No. 1 Shaft, and has been sunk on an outcrop of decomposed copper-bearing rocks, separated from the main body by a mass of felsite. (*See* Plates 5 and 6.)

The shaft has been sunk 50 feet below the floor of the open-cut, and from this a drive communicates with a winze, sunk from the open-cut down to the end of No. 2 Tunnel. The rocks on the surface show carbonate of copper in a number of places, and from various parts here, and from the shafts and drives, a maximum return of 3.8 per cent. of copper has been obtained; the general average, however, being less than 1½ per cent. of copper.

Experiments have been tried in concentrating the ore, and some of the concentrates have yielded nine dwts. of gold and traces of silver to the ton, and 20 per cent. of copper, but an estimate of the quantity of stone required to produce a concentrate of this richness has not been obtainable.

It has been considered that the copper contents of the ore in the winze is about 1.8 per cent., the ore in No. 2 Shaft probably 1.7 per cent., in the cross-cut 1.7 per cent., and in the tunnel 3.25 per cent.; but samples taken from the same workings show on an average only traces of copper, although small bodies of ore occur which yield up to three per cent .of copper. Fifty tons of ore at grass is said to have yielded three per cent. of copper, and that stone picked from this returned 17 per cent. of copper.

In the open-cut a sample was taken from across 18 feet of stone showing carbonates of copper, and this yielded 1.48 per cent. of copper; and a sample taken from a heap at No. 2 Shaft yielded 1.67 per cent. of copper.

Deposits in the Granitic Rocks.

No. 6 Tunnel.—The position of this tunnel is close to the south-west corner of No. 5 Lease, and between the workings of No. 5 Shaft and No. 1 Tunnel. It is situated low down in a gully leading from the gap between Middle Peak and North Peak, and was driven for the purpose of reaching the breccia formation. The direction taken is S. 10° E., and the distance driven 32 feet, but the work for the present is suspended.

The rock is a microgranite and represents, *in situ*, the same rock found with others as fragments in the breccia at No. 1 Shaft. Copper occurs as blebs of yellow sulphide, the percentage of copper being less than one per cent.

No. 8 Tunnel.—This is situated in about the centre of No. 3 Lease, and about 15 chains from No. 6 Tunnel. The formations it penetrates are felsite and granite, with a breccia at the end of the drive. The breccia is very compact and contains fragments of felsite, quartz felsite, and microgranite. Very little copper is present, and this is mostly associated with the fragments of quartz felsite.

On Plate 2 is represented a section along No. 8 Tunnel, and illustrates the position of the end of the tunnel with regard to the breccia which the tunnel was driven to strike, and an outcrop of which occurs on the surface to the north-west above the tunnel. Considered generally, the copper occurring in the tunnel is very small in amount, and there are very few tons of stone in sight which would yield over one per cent. of copper.

No. 2 Tunnel.—No. 2 Tunnel is to the east of No. 2 Shaft, and was driven 294 feet westerly, to prospect the breccia formation below the bottom of No. 2 Shaft. The rocks the tunnel is driven through are felsite and quartz felsite (with mica present as a rare constitutent), and a microgranite, and although the breccia of No. 2 Shaft must be very close to the tunnel it has not yet been discovered. Blebs of yellow sulphide of copper (copper pyrites) are seen in the rocks in the tunnel close to what may be considered an eastern boundary or limit of the copper-bearing formation, and on the surface above the tunnel at this eastern boundary copper shows freely on the surfaces of the brecciated rocks. (*See* Plates 5 and 6.)

The Quarry.—This excavation is about four chains easterly from No. 8 Tunnel, and is on the sides and botton of the channel of a water-course. The rocks are felsite and quartz felsite, with mica occasionally present. Portions of the rocks are somewhat brecciated, being made up of large angular blocks of felsite.

The copper occurs in the felsitic rocks very irregularly and very much scattered. Tons of the rock have been quarried (roughly about 200 tons), and from this about ten tons have been picked out, a sample of which, made up of portions of each heap of ore at the different faces in the quarry, yielded on assay 0.69 per cent. of copper and traces of gold and silver.

No. 4 Tunnel.—This tunnel is on the boundary line between No. 3 and No. 4 Leases, and to the south-east of No. 8 Tunnel. Its bearing is north-west, and the length about 140 feet. The open-cut at the entrance penetrated a mass of copper-bearing stone, but the tunnel passed through into a biotite granite, and continued in this rock to the face, the object in view being to cut a supposed extension of the copper-bearing stone found in the short tunnel above No. 4.

The ore at the mouth is contained in a felsite, a quartz felsite, and a much decomposed (?) dolerite, with veins of quartz and iron-stone. A sample for assay was stripped from the side of the open-cut and tunnel, where the ore is exposed, and yielded 2.5 per cent of copper and traces of gold and silver. The formation appears to be about five feet thick, but as the tunnel has been driven in the wrong direction, its extent has not been ascertained.

Close to the end of the tunnel a (?) dolerite dyke was penetrated, and in the granite on the other side there are veins of copper pyrites half an inch thick, but of no importance.

The top tunnel is 20 feet in length, and shows some very good carbonate, oxide, and sulphide ore, contained in decomposed aplite and quartz felsite. A sample was taken from all exposed places, and an assay yielded 3.89 per cent. of copper and traces of gold and silver.

On the roof, floor, and sides of the tunnel the ore is to be seen, but the work accomplished is not sufficient to determine its extent.

The illustration on Plate 3 represents a section along No. 4 Tunnel, and shows the position of the formations at the open-cut and at the top tunnel.

No. 7 Tunnel.—This tunnel is about five chains south-westerly from No. 4 Tunnel. Its bearing is S. 15° W., and its length is 201 feet.

The rocks at the entrance of the tunnel are somewhat disturbed. A breccia made up of quartzite fragments in a matrix of felsite occurs in granite, and in the granite there are irregular veins and patches of quartz, ankerite (carbonate of iron, lime, &c.), and calcite. In the granite close to the breccia there are a few fine veins and threads of copper pyrites with molybdenite.

The tunnel was driven to reach a body of stone supposed to extend downwards from the outcrop of copper ore on the crown of the hill, but it has not yet been found. The rocks in the tunnel are a biotite granite, a friable felspathic rock impregnated with iron pyrites, and a quartz felsite at the face containing traces of molybdenite.

The outcrop above No. 7 Tunnel shows copper carbonates with iron oxides freely distributed in a decomposed felsite. A sample was taken from the exposed places in the trenches, from about ten tons of ore at grass, and also from what was exposed *in situ* on the surface. Portions of the stone exposed in the trenches showed no copper at all, and these were not sampled. The returns from the assay showed 3.85 per cent. of copper.

Plate 4 illustrates a section of the tunnel, and shows the position of the outcrop of copper ore on the crown of the hill.

No. 3 Shaft.—This shaft is 50 feet deep, and is situated about 15 chains north-westerly from the outcrop above No. 7 Tunnel, and is on the line of section G H represented on Plate 7. The formation in which the shaft is sunk is a pale-greenish, friable, partly decomposed felspathic rock, containing abundance of cubical iron pyrites, and is not copper-bearing. About 20 feet to the south-west of the shaft a trench has been cut on an outcrop of copper-bearing rock showing carbonates. The rock is similar to that in the shaft, only more decomposed and iron-stained. The copper also occurs on the faces of a low cliff close to the trench, but the prospecting work at the base of the cliff does not show any features indicating a continuation of copper in depth, although the few tons of stone around the trench above must average two or three per cent. of copper.

No. 3 Shaft was sunk to prospect for gold as well as copper, because of the resemblance of the stone in the outcrop to some of the auriferous stone occurring in the Mount Morgan Mine, but the results were not satisfactory. The heap of stone at the shaft, which might contain about 50 tons, was sampled over the surface, and the assay of this yielded traces of copper, gold, and silver.

A sample was taken of the surface stone at the cliffs and the trenches, and from the ore at grass, but only stone was taken in which copper was present, barren portions being excluded. This sample yielded 0.96 per cent. of copper and traces of gold and silver.

The rock in which No. 3 Shaft has been sunk, evidently extends south-easterly to the outcrop above No. 7 Tunnel, and also below to the tunnel level as shown in Plate 4.

Copper is also present in the rocks of the same belt about 50 feet to the north-west of the outcrop above No. 7 Tunnel. A small excavation has been made, and the ore exposed shows a resemblance to that above No. 7 Tunnel.

Other Localities.—An old abandoned shaft situated easterly from No. 5 Shaft was examined. It is 15 feet deep, and is sunk on a decomposed felsite traversed by a vein of aplite, both of which were found to be impregnated with copper carbonates and copper pyrites. The appearance of the vein suggests that more should be known as to its extent. Copper carbonates also occur on the surface of the ridge further to the east.

Another old shaft, 25 feet deep, situated south-east of No. 7 Tunnel, and outside No. 4 Lease, was examined. The formation is a decomposed felsite and granite, with fine veins of carbonate and oxide of copper. About one ton of stone is lying about on the surface containing, perhaps, five per cent. of copper, but the bulk of the stone taken out does not show copper at all.

Cupriferous Sandstones.

North Tunnel.—This tunnel is situated on the central one of the three leases north of those belonging to the Moonmera Copper Company, and is about ten chains east of North Peak.

The formation is sandstone, more or less ferruginous and clayey in parts, with interbedded gritty ferruginous tuffs. The sandstones are impregnated with blue and green carbonates of copper and the red oxide (cuprite), while the red tuffs in patches are spotted with the carbonates.

The tunnel is driven westerly along the dip of the copper-bearing sandstones, which are exposed for some distance along its sides and at the face. Samples were taken from all the exposed places in the tunnel showing copper, also from one ton of picked ore at the entrance, and from about 20 tons of ore in the paddock near the entrance. The result of this, on assay, gave one per cent. of copper, and traces of gold and silver.

Cliffs near South Peak.—On the edge of the cliffs to the east of South Peak, which is the most southerly of the three prominent peaks on the Moonmera Range, there is an exposure of the cupriferous sandstones below the regular-bedded Coal Measures. This formation extends northerly and southerly (*see* Map 2), and shows traces of copper in several places.

On an exposed cliff, about twelve chains south-east of South Peak, marked "Copper" on Map 2, the sandstones are impregnated with carbonates and red oxide of copper, some portions of which undoubtedly are very rich. Concerning these rich portions no definite opinion can be expressed, as they are simply outcrops, their richness probably being due to the leaching out of the copper from sandstone not exposed, and deposition taking place on the sides of the cliffs. The sample taken from here yielded 2.68 per cent. of copper, and traces of gold and silver.

Other Outcrops.—Sandstones, containing rich patches of carbonate of copper, occur in numerous other places along the cliffs, and some of these patches of ore undoubtedly have been formed by the leaching out of the copper to form efflorescences below the overlying rock ledges.

Summary of Mining Work.

In reviewing all the work which has been in progress at the Moonmera Copper Mines, it becomes apparent that, although some of the prospecting work has yielded satisfactory results, most of the work has been unsuccessful in establishing the existence of well-defined bodies of copper ore.

A few of the outcrops show signs of being permanent, but others are irregular and unreliable in their occurrence. That copper ore exists in enormous quantities is unquestionable, as outcrops of ore can be observed in a vast number of places high up on the mountain slopes in the sandstones and breccia, and lower down in the belt of granitic and felsitic rocks.

Of the most promising localities where developments have exposed the formations carrying copper, or are in positions favourable for working, No. 6 Tunnel should first be mentioned. The further extension of this tunnel may not be in accordance with the scheme of development laid down; but, after all, it is more important to first prospect the ore bodies and find out their value, than to put in levels for working the mine and then prospect for ore-bodies afterwards.

Quite possibly No. 6 Tunnel would reach the breccia if extended a short distance, and the finding of this formation so far below No. 1 Shaft would reveal what its character and quality are in depth.

No. 1 Shaft and No. 1 Tunnel are favourably situated, and should it be found advisable to further prospect the breccia, these workings will be found to be in a good position for development.

The developments at No. 2 Shaft in the breccia formation show very decidedly what the stone is like in this neighbourhood, but as No. 2 Tunnel has failed to reach the breccia, an alteration in the direction of the tunnel by driving more to the north would probably be more successful, as the inclination of the breccia formation is north-westerly.

No. 8 Tunnel, as well as penetrating the breccia exposed above the tunnel, is also prospecting the breccia in which No. 2 Shaft is put down. Both these workings are on the same belt, the outcrop of which extends from No. 2 Shaft in a north-easterly direction to the hill in which No. 8 Tunnel is driven.

The Quarry, near No. 8 Tunnel, does not yield any definite information concerning the trend of the rocks in the neighbourhood. Although there are possibilities of its being connected with the copper outcrops at No. 4 Tunnel as has been supposed, there is very little evidence to be obtained from it on which to base an opinion, and the copper belt, if such a thing exists, might be in quite a different direction. The individual outcrops in this part of the granite area, and also in other parts, are so numerous that it would be very easy to fall into the error of supposing that a connection exists between several of them, and to assume that they were the various outcrops belonging to more or less defined lode formations.

Work should not be continued at No. 4 Tunnel, unless it is to explore the small formations passed through on the east side, but the tunnel above No. 4 Tunnel, named the "Top Tunnel" on Plate 3, should be prospected, if it were found necessary to determine the extent of the ore body there.

In No. 7 Tunnel work should not be continued until the outcrop above it on the crown of the hill has been further examined and more known about its trend.

In No. 3 Shaft the stone has been sufficiently tested to show its quality, and no encouragement can be given to do any additional work here.

Attention is directed to the outcrop of copper-bearing sandstone south-east of South Peak, where prospecting might reveal a body of ore. The stone is good in quality, and, although it might only be rich where exposed, quite possibly it extends into the hill for some distance.

Concerning the North Tunnel, the examination shows that a regular and permanent formation of sandstone of about four feet in thickness is present, and there is every indication of the copper carbonates in it continuing into the hill to the south.

Generally considered, the exploratory work indicates that the copper ore in the granitic and felsitic rocks has failed to give good results, and except where they may furnish some information regarding the occurrence of the breccia, with which they come in contact, it is questionable whether any further exploitations should be made in

them. If anything is done, the breccia is the formation in which attention should be more concentrated, but limited to those places previously referred to, while the outcrops of copper-bearing sandstones should not be neglected.

Regarding the mining work, a few words of advice may not be out of place. The practice of putting in large tunnels for development and for working out the ore bodies, before the character of the deposits is understood, is not to be commended under any conditions, and at Moonmera it is evident the deposits have not been understood, from the failure of most, if not all, of the tunnels to penetrate the ore bodies which they were put in to test. Impregnations of granite or felsite, or other such rocks, are always of an uncertain character, and very different to a well-defined lode formation or vein, and so their exploitation should be undertaken on lines altogether different to that which has been followed.

Concerning concentration, it may be stated that, as the ore is a low grade one, it would be necessary to adopt some method of reducing the proportion of gangue to mineral prior to metallurgical treatment. There are very large quantities of ore containing traces up to about two per cent. of copper, and while much of the ore cannot be hand-picked, some of it could be treated in this way, on account of the favourable condition in which the minerals occur in the gangue.

Crushing and concentrating some of the ore could be satisfactorily performed, as trials have shown, and the latest return available shows that 7½ tons, taken from No. 2 Shaft, were concentrated to 16 cwt. containing 12.5 per cent. of copper and six dwt. of gold.

LIST OF MINERALS.

NAME OF MINERAL. OCCURRENCE.

Ankerite.—This iron-lime carbonate is associated with calcite and quartz crystals in decomposed granite at the mouth of No. 7 Tunnel. (*See* Plate 4.) The quartz crystals occur in vughs on which the ankerite, in a massive crystalline form, has been deposited. The calcite is a subsequent crystallisation on the ankerite and quartz. The mineral is white, but rapidly oxidises to a yellow colour on a freshly-exposed surface.

Atacamite.—An oxi-chloride of copper occurring with halite (sodium chloride) on the surface of a friable sandstone near the North Tunnel. Rare.

Azurite.—Blue carbonate of copper. Found in numerous places all over the field. At the North Tunnel it is in the form of small lenticular scales in tuffs and sandstones, and also as impregnations in the latter rocks.

Biotite.—A common mica in the older granites about Moonmera.

Calcite.—In No. 7 Tunnel, associated with quartz and ankerite.

Chalcedony.—Occurs in the felsite in the quarry near No. 7 Tunnel as an encrustation on quartz crystals. Originally the quartz crystals were embedded in copper pyrites, but the latter mineral has been removed and the chalcedony has formed on the crystal faces.

Coal.—Inferior coal occurs on the Moonmera Range, in Mesozoic rocks. (*See* Plates 6 and 7, and Map 2.)

Copper Pyrites.—The matrix of this material is usually the granitic rocks, but it occurs in many different varieties of the acid rocks, noticeably where in contact with those more basic in composition. In the lower outcrops of the breccia it is also found.

Cuprite.—This oxide of copper occurs near the surface of the copper-bearing rocks in the granites and felsites, but it is found far below the surface in the breccia. It is also present in the sandstones on the Range.

Copper Glance.—At No. 1 Shaft and No. 1 Tunnel in small bodies.

Dolomite.—Common as patches and veins in the Moonmera-Moongan railway cuttings.

Galena.—Traces found with the copper pyrites in several of the mine workings.

Gold.—In veins and reefs at Mount Scott, &c. As alluvial deposits in the watercourses east and west of Moonmera Range.

Hematite.—Occurs in the copper-bearing outcrops, and in the sandstones and tuffs on the Range.

LIST OF MINERALS—*continued.*

NAME OF MINERAL. OCCURRENCE.

Halite.—Formed as an exudation in the caves in the sandstone cliffs of the Range.

Hornblende.—In the syenites and diorites in the railway cuttings.

Iron Pyrites.—Common in the Moonmera mine workings; abundant at No. 3 Shaft and No. 1 Tunnel.

Limonite.—On the outcrops of the copper-bearing rocks; also in the sandstone on the range.

Malachite.—Found in numerous places on the field. At North Tunnel impregnates the sandstones.

Melaconite.—Occasionally found as a black coating to the copper pyrites in the mine workings.

Molybdenite.—Filling the joints and occurring as flakes in some of the felsites; occasionally as small masses a few inches in diameter.

Muscovite.—In some of the newer granite veins in the railway cuttings, and in the older decomposed granite.

Native Copper.—In the breccia and sandstones in several places, particularly about No. 1 Shaft and No. 1 Tunnel.

Quartz Crystals.—At No. 7 Tunnel and in the quarry near No. 8 Tunnel.

Vermiculite.—In abundance in the veins of granite and pegmatite in the railway cuttings between Moonmera and Moongan. It is in small scales, having very much the appearance and habit of muscovite. Before the blowpipe it exfoliates remarkably; then fuses to a black glass.

ALTITUDES (APPROX.)

	FEET.		FEET.
Middle Peak	1,350	No. 2 Tunnel	880
South Peak	1,300	No. 8 Tunnel	850
North Peak	1,300	Quarry	795
Gap South of Middle Peak	1,250	No. 6 Tunnel	780
No. 1 Shaft	1,050	No. 5 Shaft	778
North Tunnel	1,050	Top Tunnel (above No. 4 Tunnel)	750
No. 1 Tunnel	1,015	Trenches above No. 7 Tunnel	790
Coal Seam Outcrop	1,010	No. 7 Tunnel	680
No. 2 Shaft	975	No. 4 Tunnel	675
Moongan Railway Station	970	Moonmera Railway Station	593
No. 3 Shaft	960	Scott's Creek at Railway Line	548
¼-mile west of Middle Peak	900		

Brisbane, 2nd September, 1902.

B. DUNSTAN,
Acting Government Geologist.

By Authority: GEORGE ARTHUR VAUGHAN, Government Printer, William street, Brisbane.

PLATE 1.

Geological Section across Moonmera Range.

The geological section across Moonmera Range along the curved line A, B, C, D, on Map 2, shows most of the formation of the district. The granite with the felsite and quartz felsites are the basement rocks, on which have been deposited the copper-bearing breccia to the east and the conglomerates to the west of the Moonmera Range, and above these are the sandstones, tuffs, and inferior coal seams of the Mesozoic Coal Measures.

The altitudes are approximate.

Geological Section across Moonmera Range

SECTION ALONG LINE A B.C.D. ON MAP 2.

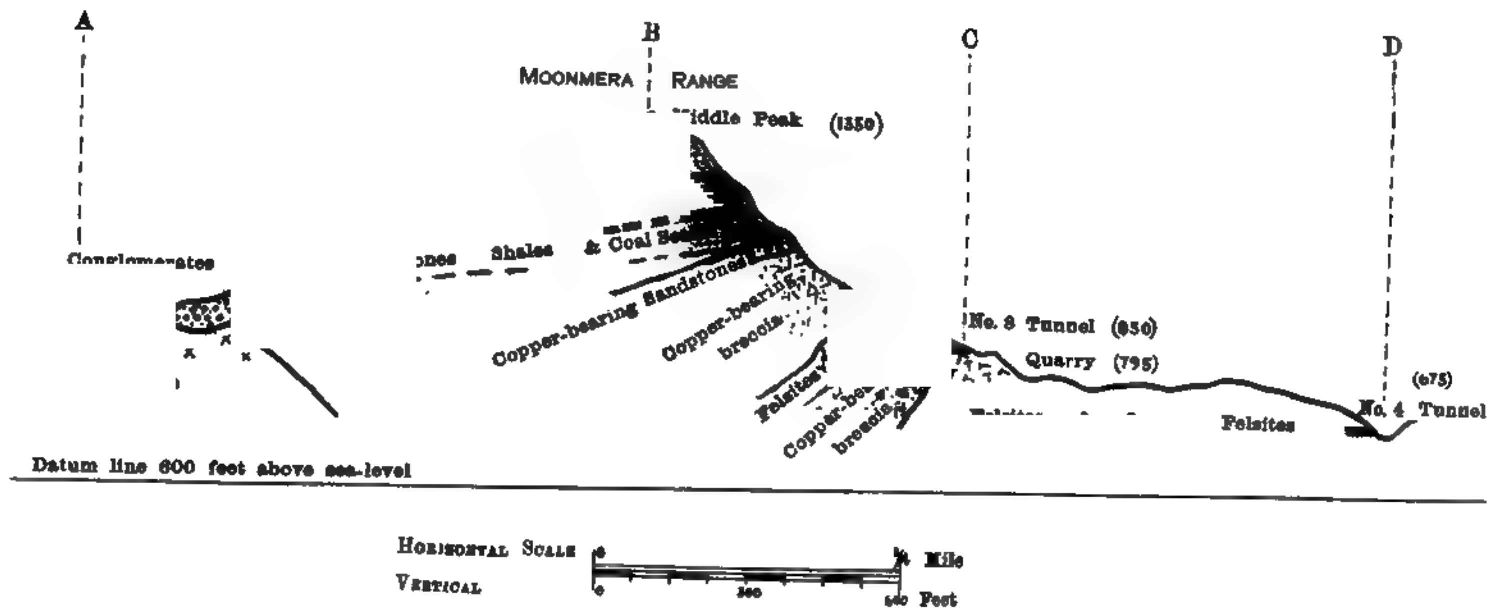


PLATE 2.

Geological Section (East of Moonmera Range) on Line B C.

The section along the line B C, on Map 2, illustrates the position of the geological formation at No. 8 Tunnel and No. 1 Shaft. At the top of the section are the Coal-Measure sandstones, shales, and tuffs, below which, at a steeper angle of dip, are the copper-bearing sandstones. The felsite "horse" seems to be enveloped by the breccia, and distinct from the mass of felsites further east in No. 8 Tunnel.

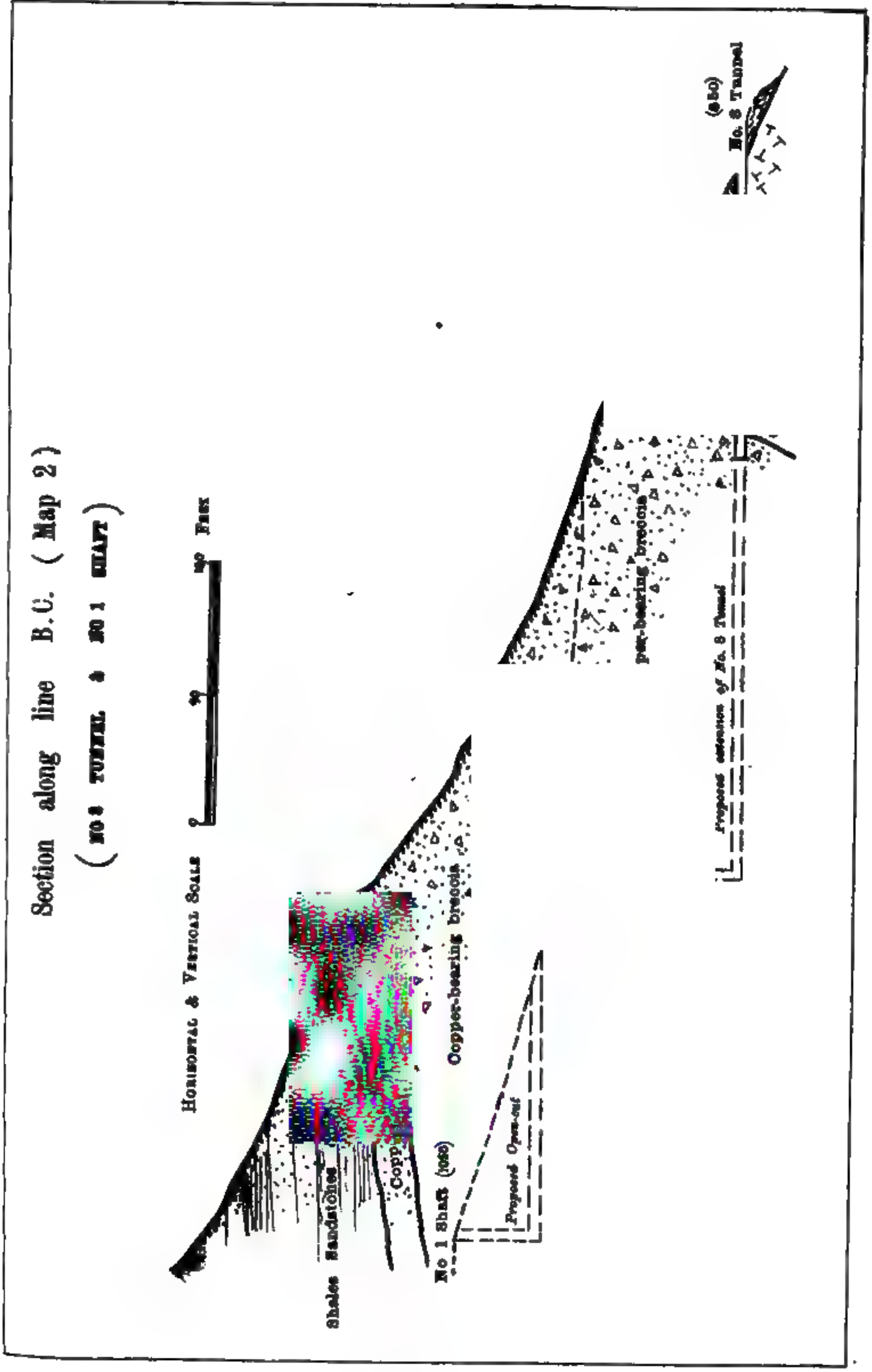

Section along line B.C. (Map 2)
(No 8 Tunnel & No 1 Shaft)
Horizontal & Vertical Scale
0
50
100 Feet
Shales
Sandstones
Copper-bearing breccia
Proposed Open-cut
Proposed extension of No. 8 Tunnel
No. 8 Tunnel

PLATE 3.

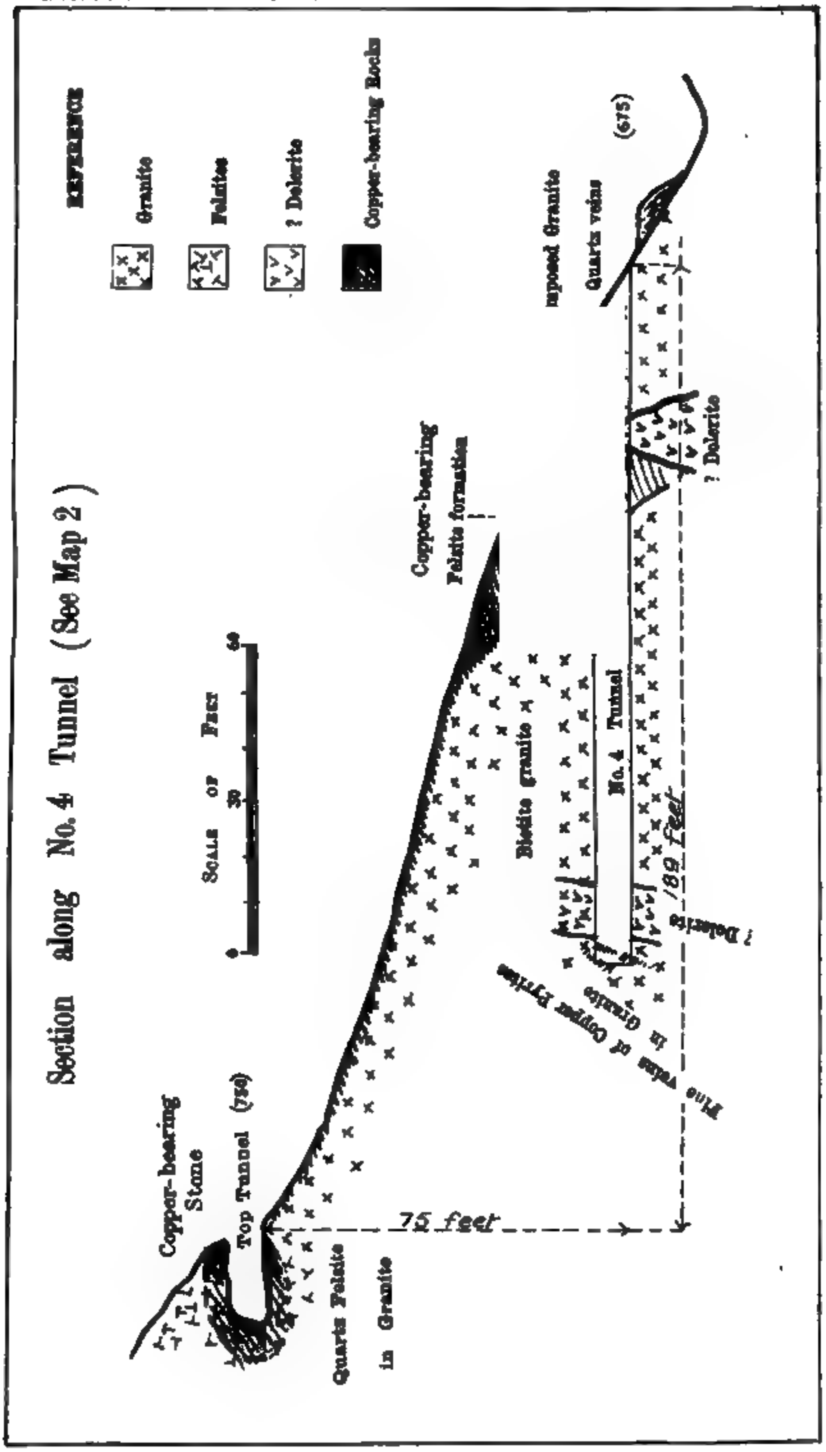
SECTION ALONG No. 4 TUNNEL.

The section along No. 4 Tunnel shows the copper-bearing vein in the granite and its relation to the (?) dolerite with which it comes in contact. The course of the copper-bearing vein is at an angle with the direction of the tunnel, and, in consequence, the vein has been cut and passed through obliquely. At the end of the tunnel a few half-inch veins of copper pyrites in granite was found near another (?) dolerite dyke, but of limited extent.

The Top Tunnel copper impregnates the granite and quartz-felsite, but no lode formation exists.

Further references to No. 4 Tunnel are made on page 21.

Plate 3



Section along No. 4 Tunnel (See Map 2)
REFERENCE
Granite
Felsites
? Dolerite
Copper-bearing Rocks
SCALE OF FEET
Copper-bearing Stone
Top Tunnel (750)
Quartz Felsite in Granite
75 feet
Copper-bearing Felsite formation
Biotite granite
No. 4 Tunnel
189 feet
? Dolerite
Fine veins of Copper Pyrites in Granite
? Dolerite
Quartz veins
(675)

PLATE 4.

SECTION ALONG NO. 7 TUNNEL.

The section along No. 7 Tunnel exposes near the entrance a dyke of felsite with included quartzite fragments, and contained between walls of granite. Quartz with ankerite occurs in the dyke, and molybdenite with copper pyrites exists as fine veins and threads in the decomposed granite close by. A friable felspathic rock penetrated in the tunnel appears to be the same rock exposed on the crown of the hill just above it. Copper occurs in the outcrop on the hill, but has not been found in the tunnel. At the end of the tunnel threads of molybdenite make their appearance in the quartz felsites. Further references to No. 7 Tunnel are made on page 22.

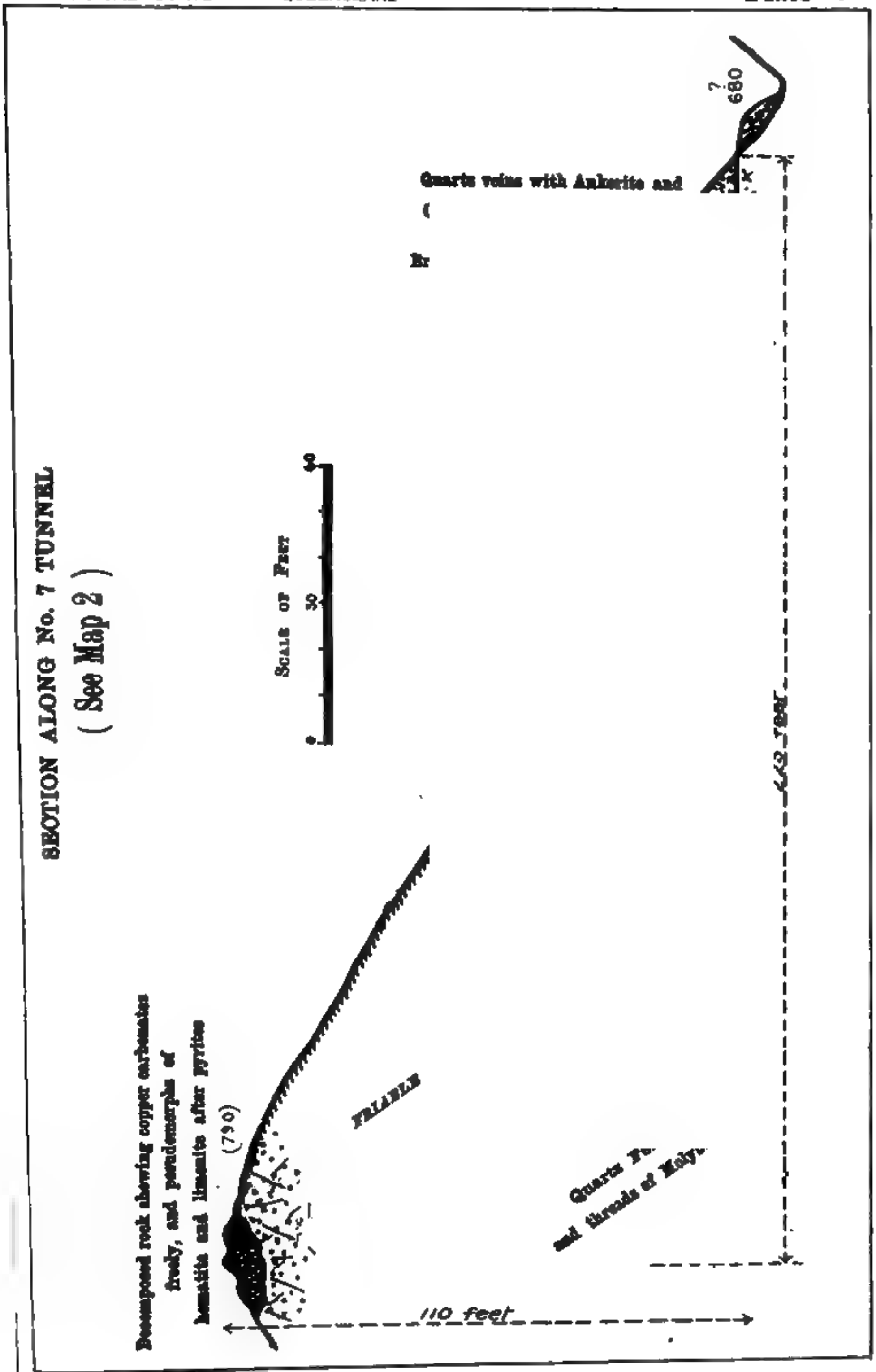
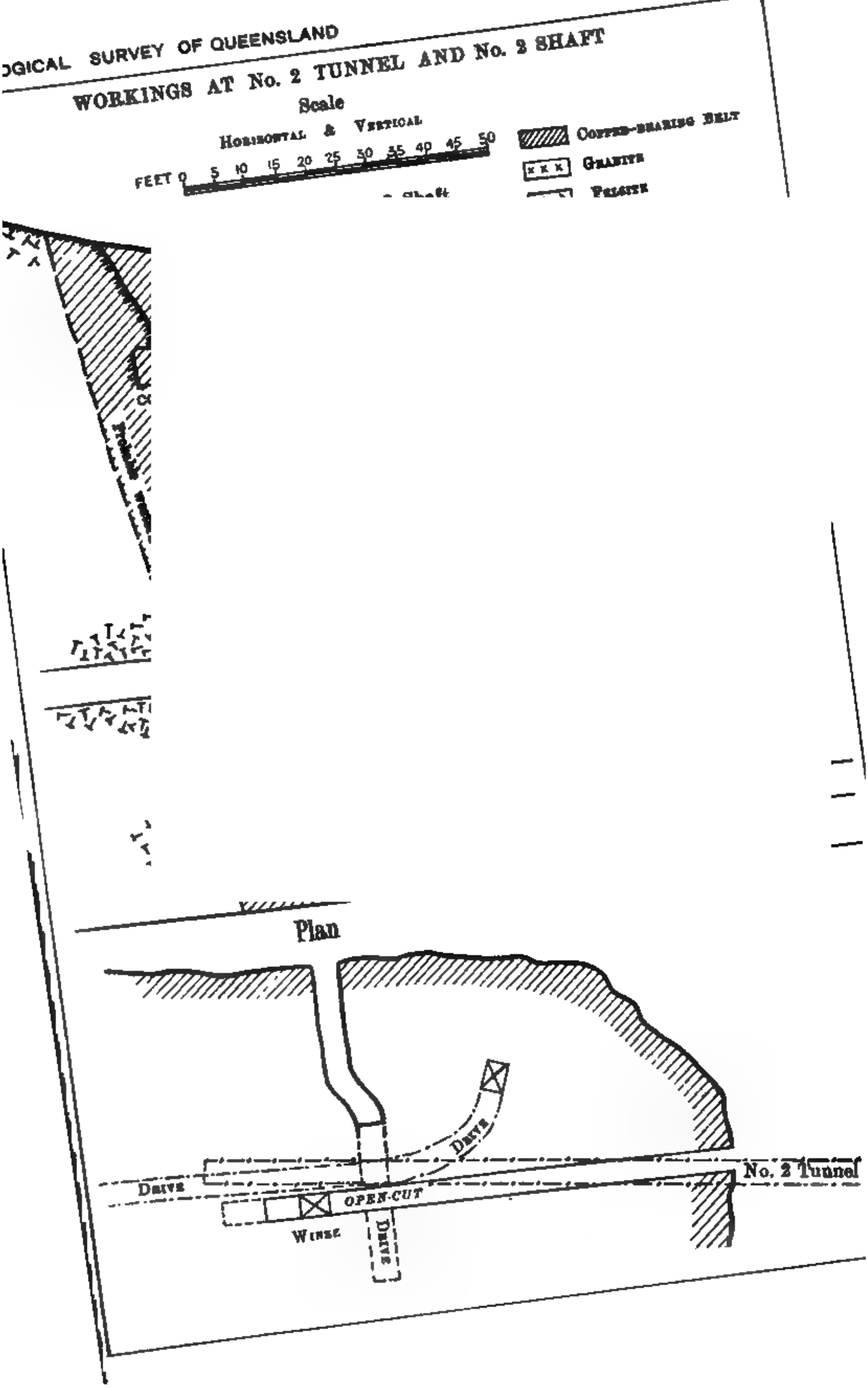

SECTION ALONG No. 7 TUNNEL
(See Map 2)
SCALE OF FEET
0
30
60
Decomposed rock showing copper carbonates
freely, and pseudomorphs of
hematite and limonite after pyrites
(790)
FRIABLE
110 feet
?
680
Quartz veins with Ankerite and

PLATE 5.

No. 2 Tunnel and No. 2 Shaft.

The workings of No. 2 Tunnel and No. 2 Shaft are shown in plan and section. The copper-bearing formation lies between granite and felsites, and apparently has an easterly underlie. The cross-hatching represents the portion found to be copper-bearing stone, independently of the kind of rock containing the mineral. References to the copper contents of the workings are given on pages 20 and 21

Plate 5



OGICAL SURVEY OF QUEENSLAND
WORKINGS AT No. 2 TUNNEL AND No. 2 SHAFT
Scale
Horizontal & Vertical
FEET 0 5 10 15 20 25 30 35 40 45 50
Copper-bearing Belt
Granite
Felsite
Plan
Drive
Drive
Drive
Open-Cut
Winze
No. 2 Tunnel

PLATE 6.

Geological Section from Moonmera Range to Quarry.

The geological section from Moonmera Range to the quarry, along the line E F, on Map 2, illustrates the slightly-inclined Coal-Measure sandstones, shales, and tuffs, the steeply-inclined copper-bearing sandstones, and the felsite mass between the latter formation and the copper-bearing breccia further east.

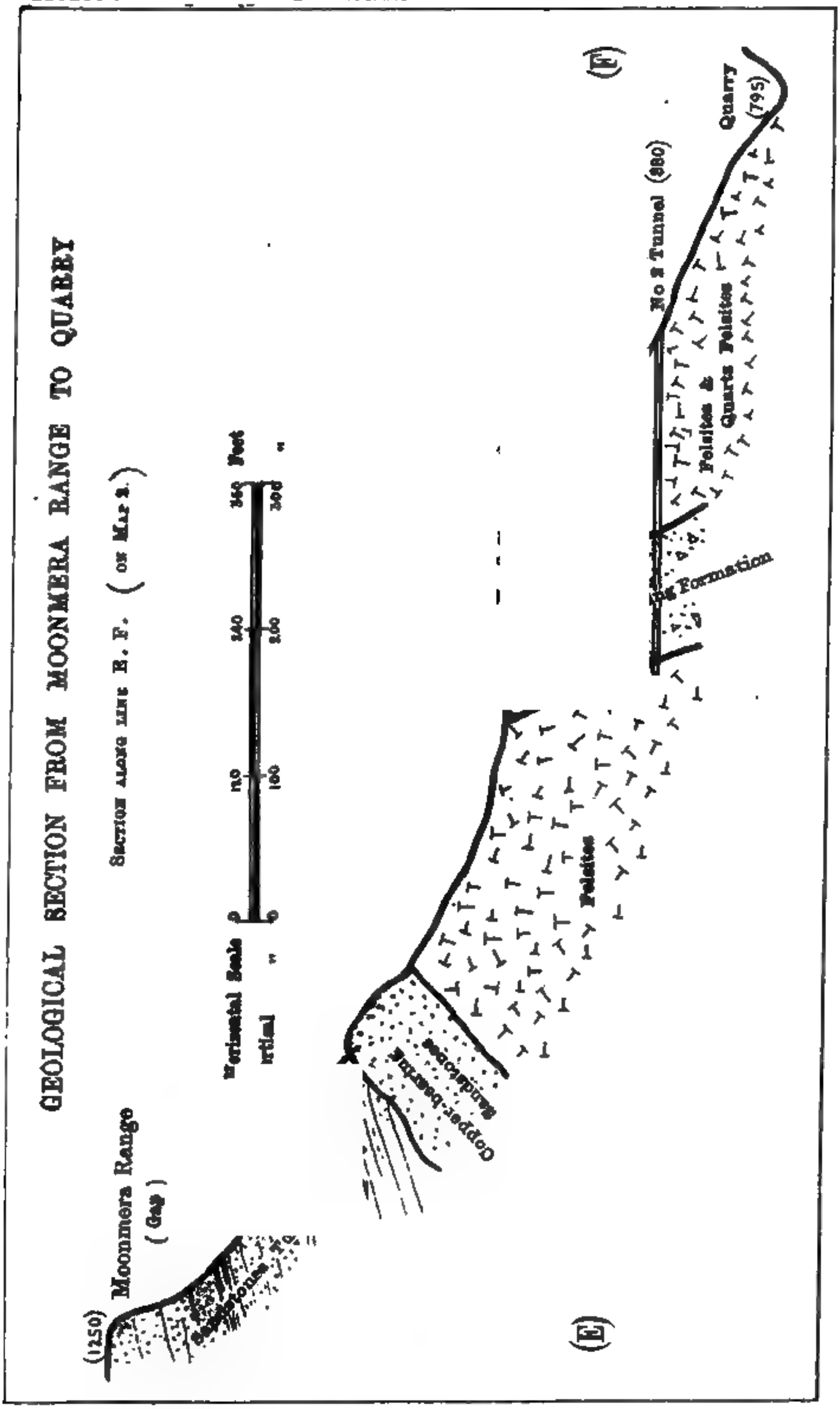

GEOLOGICAL SECTION FROM MOONMERA RANGE TO QUARRY
SECTION ALONG LINE E. F. (ON MAP 2.)
Horizontal Scale
Vertical
0
120
240
360
Feet
0
100
200
300
Moonmera Range
(Gap)
(1250)
Sandstones
Copper-bearing Sandstones
Felsites
Felsites & Quartz Felsites
No 2 Tunnel (880)
Quarry
(795)
(E)
(F)

PLATE 7.

a

Section East of Moonmera Range.

Section along the line G H, on Map 2, between South Peak and No. 3 Shaft. It shows the steep angles at which the irregular cupriferous sandstones are inclined to the west, and also the less inclined overlying Coal Measures.

A White tuffs.
B Sandstones.
C Shales with coal.
D Copper-bearing sandstones.
E Felsites.

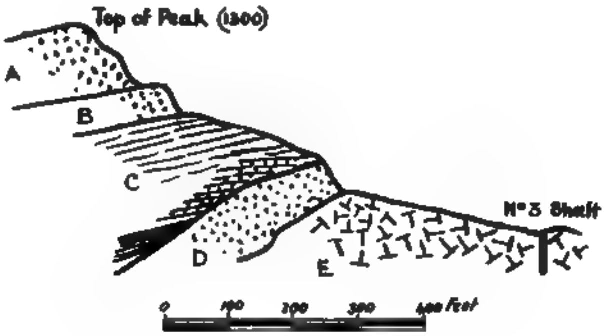
b

Breccia at No. 5 Shaft.

A section of breccia from No. 5 Shaft, showing the angular and sub-angular fragments of a bluish quartzite (*b*) in a matrix of felsite (*a*). A microscopic section showed the quartzite to be made up of fragments much altered and of varying degrees of fineness, and to contain magnetite dust.

Scale: 1 inch = 6 inches.

(*a*)



(*b*)

PLATE 8.

Section from Railway Cutting (A).

In this section large and small dykes of diorite have penetrated what is probably a broken-up mass of felsite included in a larger mass of diorite. A vein of fine-grained aplite and granite has been formed in the diorite and felsite.

Mica and hornblende occasionally occur in the diorite and felsite.

The horizontal diorite masses would appear to have been previously connected with one another, but taken in conjunction with the section (A) illustrated on Plate 15, it is evident that an open fissure in the felsite was formed, subsequently faulted, and then filled with diorite.

Scale: 1 inch = 12 feet.

Plate 8

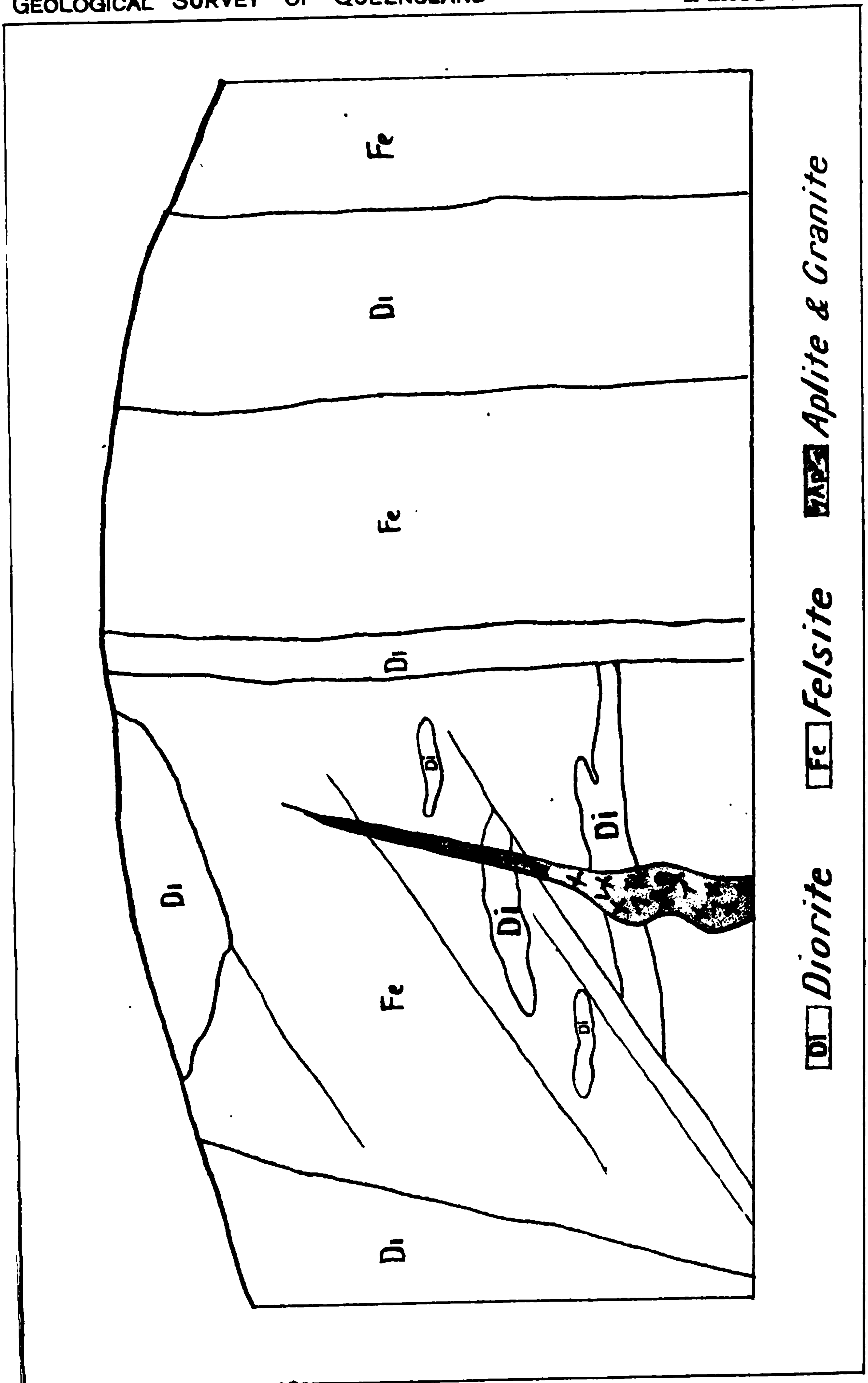


PLATE 9.

Section from Railway Cutting (A).

An enlarged view of the aplite and granite vein shown on Plate 8. The section illustrates the system and joints in the felsite and the silicification of the felsite where it comes in contact with the aplite and granite. The silicification, however, is not limited to where the two rocks are in contact, as it occurs along some of the joints (shown dotted) in the felsite.

The aplite is fine-grained in places, almost felsitic, but also occurs of a coarse-grained texture and graduates into a vermiculite granite.

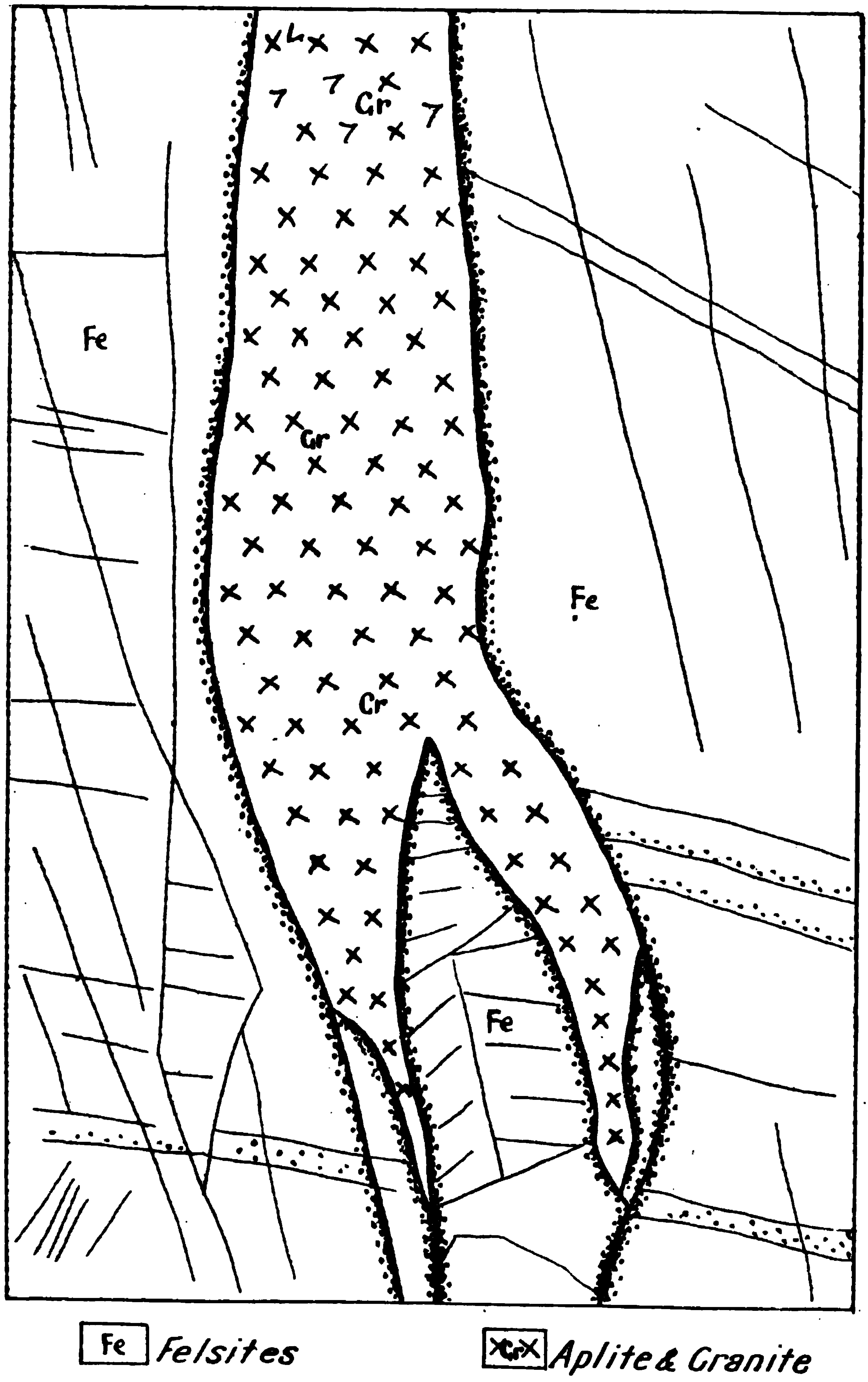

Gr
Fe
Gr
Fe
Gr
Fe
Fe Felsites
Gr Aplite & Granite

PLATE 10.

a

SECTIONS IN RAILWAY CUTTING (B).

A felsite mass in the railway cutting (B), shown on Map 1, has been intruded by a diorite dyke. Subsequently the two rocks, as one mass, have been faulted, and in the resulting fissure an aplite has been formed, this rock graduating into a clean quartz in the smaller parts of the vein.

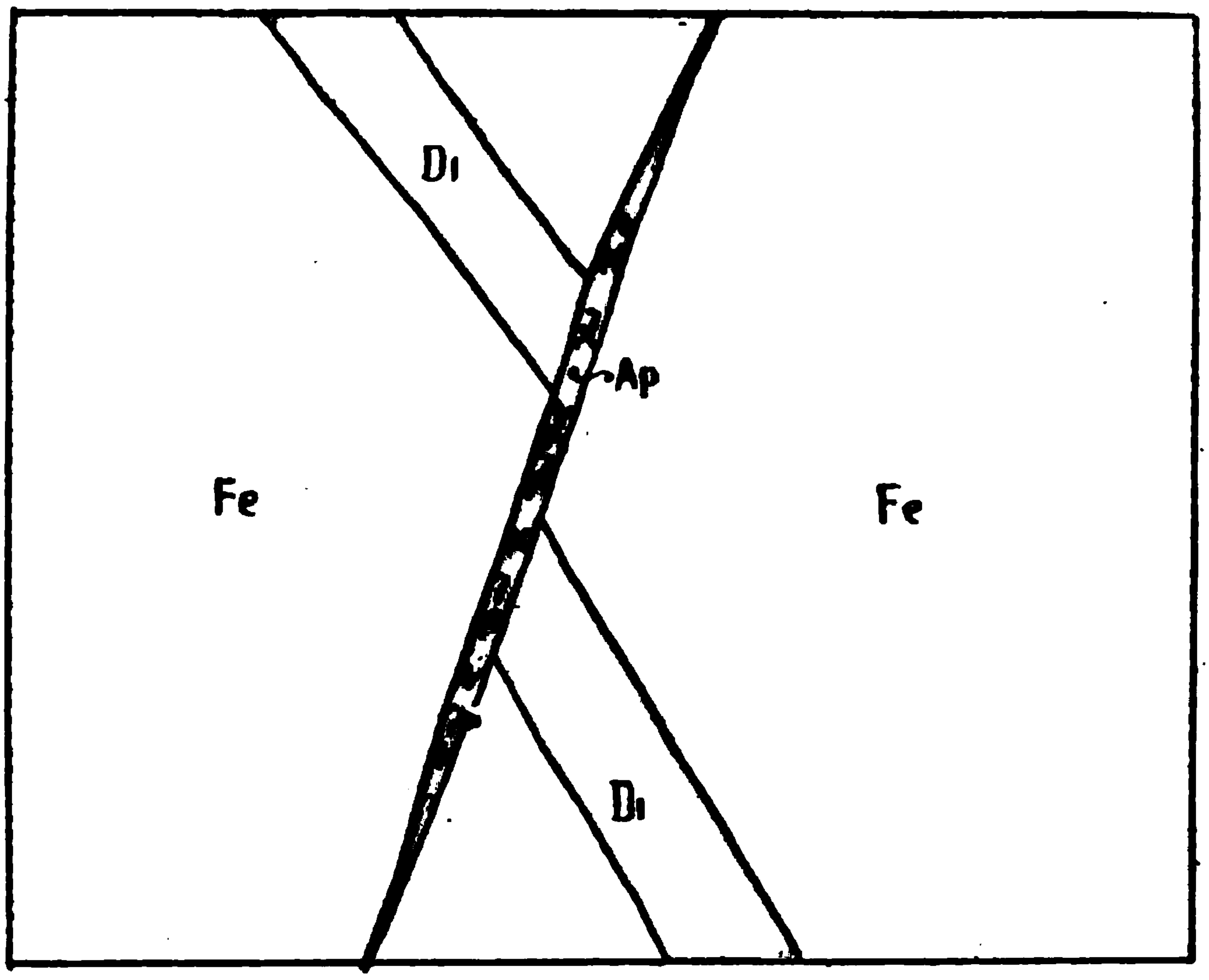
Scale: 1 inch = 8 inches.

b

Aplite and pegmatite granite veins have been formed in the massive syenite, across both of which a series of small veins of aplite has more recently been formed.

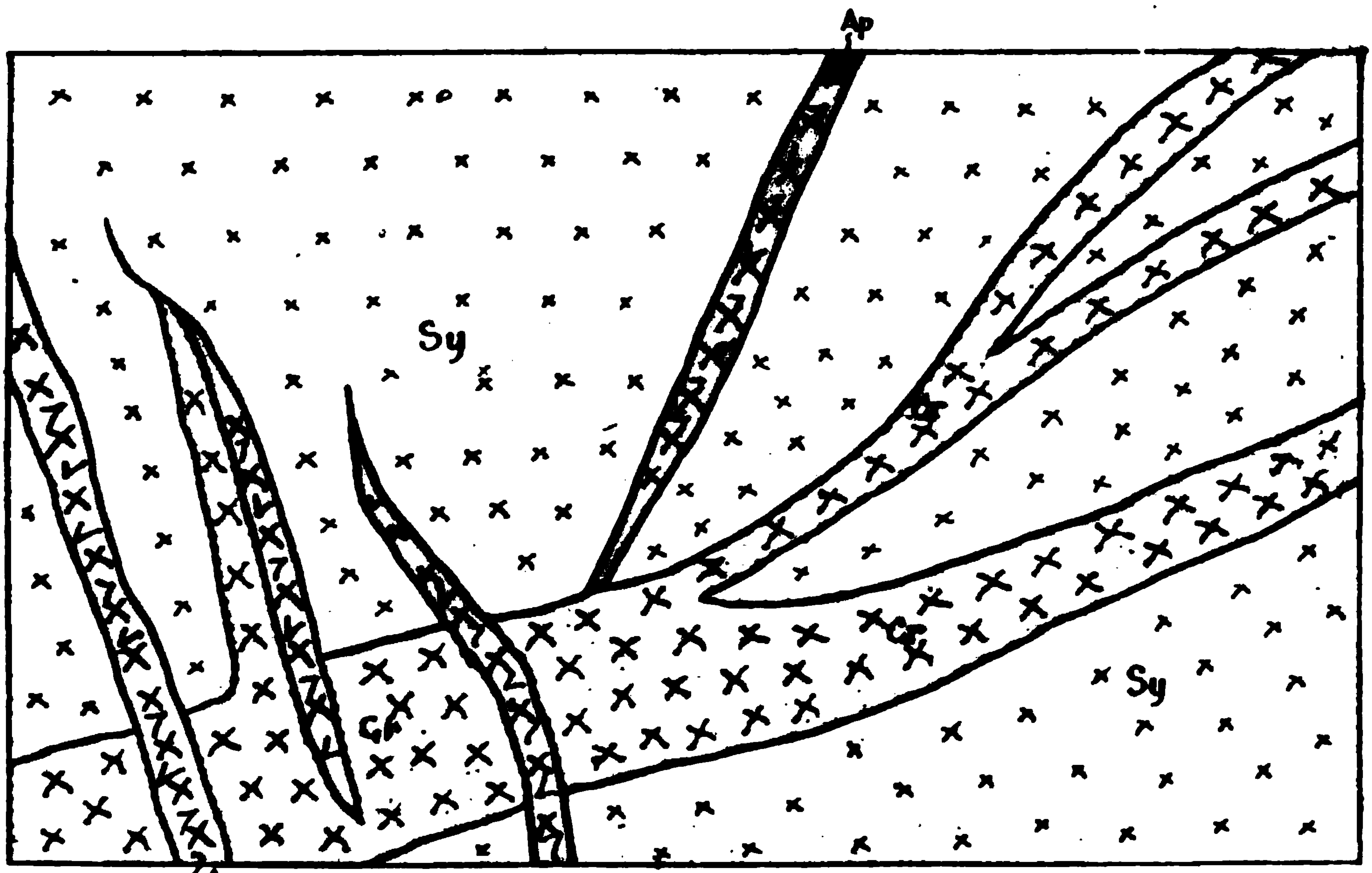
Scale: 1 inch = 14 inches.

(a)



Fe Felsites Di Diorite Ap Aplite

(b)



Sy Syenite Gr Cranite Ap Aplite

PLATE 11.

Section in Railway Cutting (B).

In this section the diorite (Di.) has been faulted, and a mass of vermiculite granite (Gr.) has been formed in the fissure. Across the diorite and granite some veins of aplite (Ap.) and quartz have been subsequently formed.

Scale: 1 inch = 3 feet.

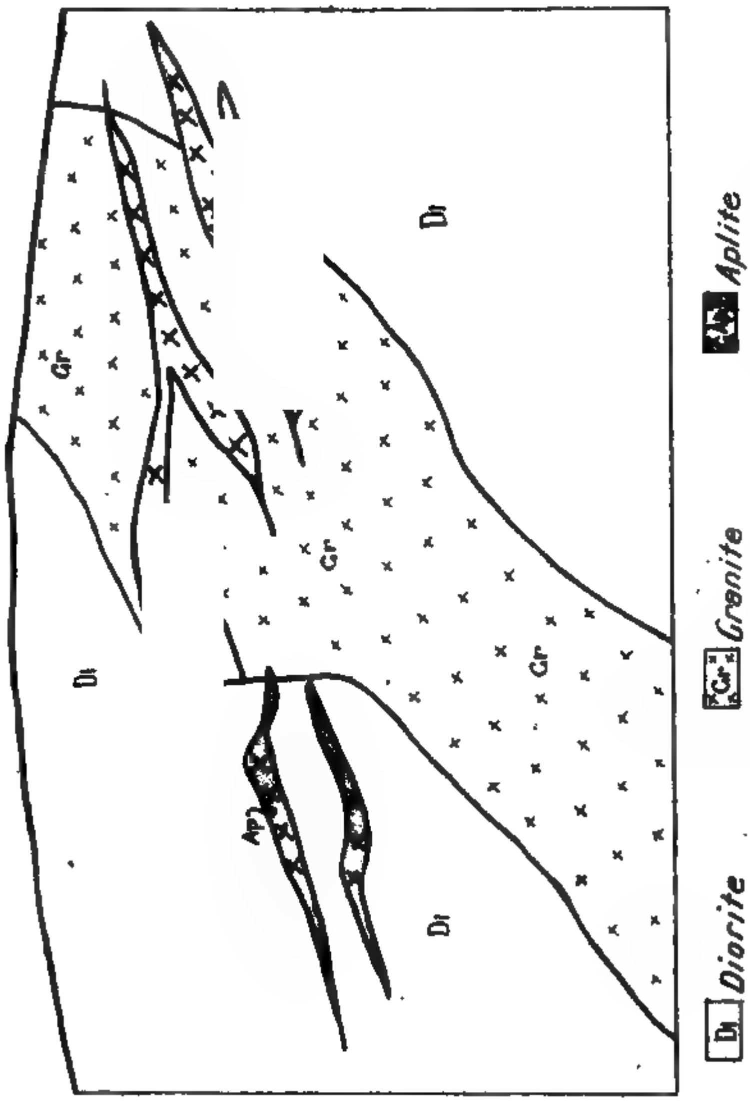

Di
Gr
Ap
Di
Gr
Di
Gr
Di Diorite
Gr Granite
Ap Aplite

PLATE 12.

SECTION IN RAILWAY CUTTING (C).

In this section the massive fine-grained granite has been broken up into blocks, and faulted along the joint planes. The character of the faulting and the formation of short gashes show that the granite has not been in a rigid condition.

The veins of the vermiculite granite are probably the equivalent of the granite in the section on Plate 11, while the massive rock would be the equivalent of the oldest (*a*) granite. (*See* Plate 19.) The vermiculite granite is coarse-grained. Under the microscope the felspar is seen to be decomposed, and while some of the mica, evidently undecomposed biotite, is strongly pleochroic and coloured green, other portions are not pleochroic and are coloured deep brown.

Scale : 1 inch = 6 feet.

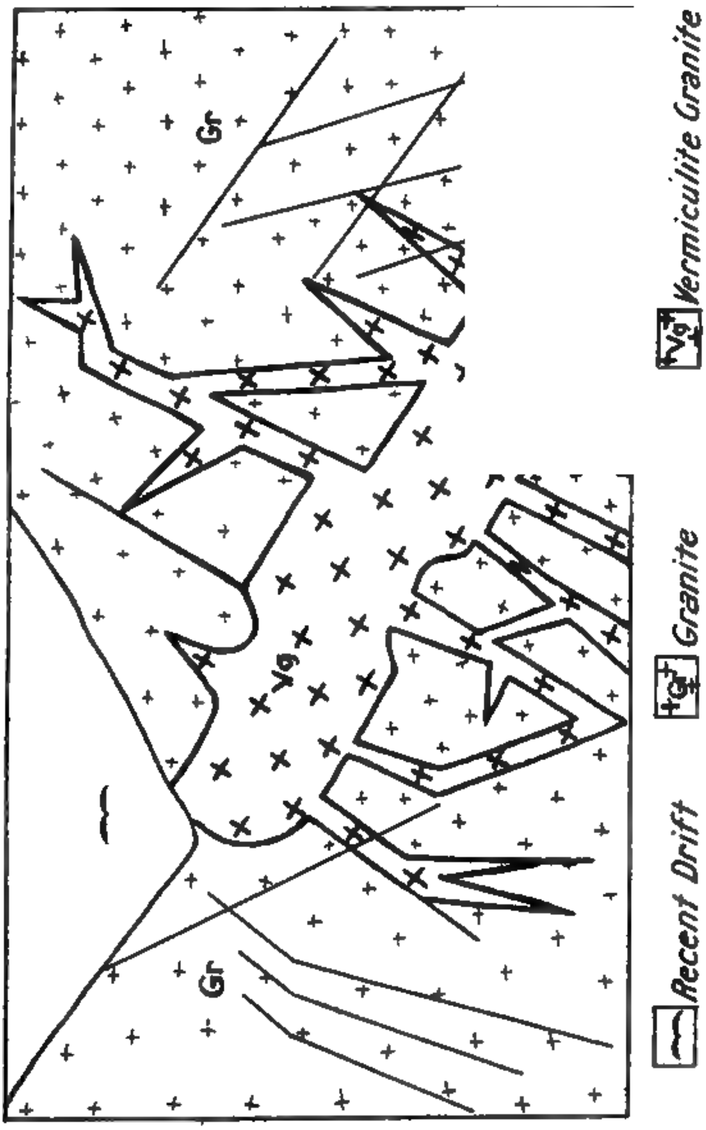

Gr
Vg
Gr
Recent Drift
Granite
Vermiculite Granite

PLATE 13.

a

Section between Railway Cuttings (E) and (F).

The section indicates that, without any apparent faulting, an opening has been made in the syenite in which a 6-inch vein of coarse pegmatite granite has formed. The branch fissure appears to have originated simply by the widening of a crack, the irregularities in the top and bottom walls showing they were once in contact.

Scale: 1 inch = 14 inches.

b

Section in Railway Cutting (F).

A diorite has been dislocated, and in the fissures which have been opened veins of fine-grained biotite (*b*) granite—marked Gr. 2—have been formed. Afterwards the diorite and the veins of fine-grained granite have been disturbed and faulted, and the opening made has been filled with a vein of coarse-grained (*c*) vermiculite granite (marked Gr. 3).

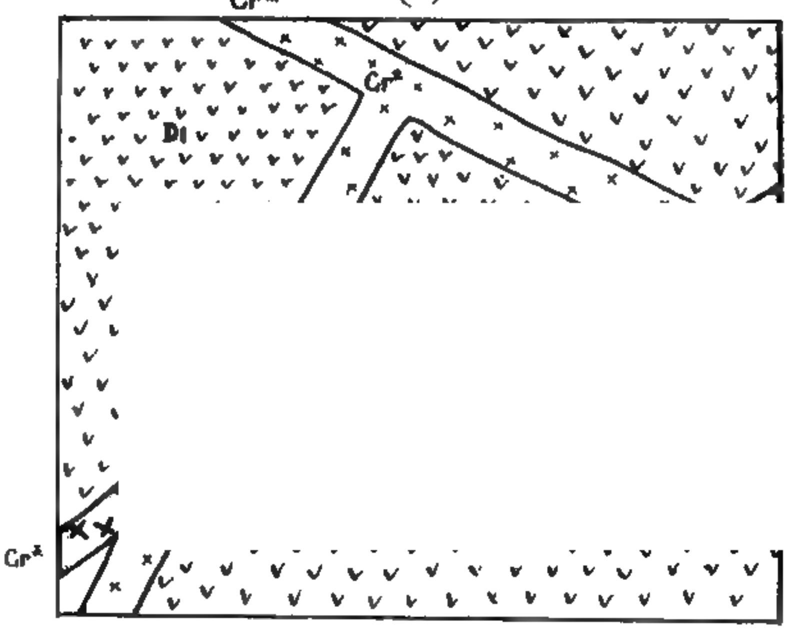
To produce the effect shown in the illustration—the faulting of one of the veins of the granite (Gr. 2) apparently without the other—the later faulting has taken place at an angle with the plane of section, being approximately along the direction of the strike of the branch vein inclined to the left, this also being along the direction of dip of the vein inclined to the right.

Scale: 1 inch = 5 inches.

(*a*)

Syenite *Granite*

(*b*)



Granite vein Di *Diorite* *Granite vein*

PLATE 14.

SECTION IN RAILWAY CUTTING (F).

A diorite (Di.) has enveloped a "horse" of felsite (Fe.), and across the felsite and diorite some vermiculite (c) granite veins—marked Vg.—have been formed. The shape of the veins of granite shows that openings had been made in the diorite, and that (c) granite subsequently filled them—the granite being an *after effect* of the disturbance of the diorite.

Scale: 1 inch = 1 foot.

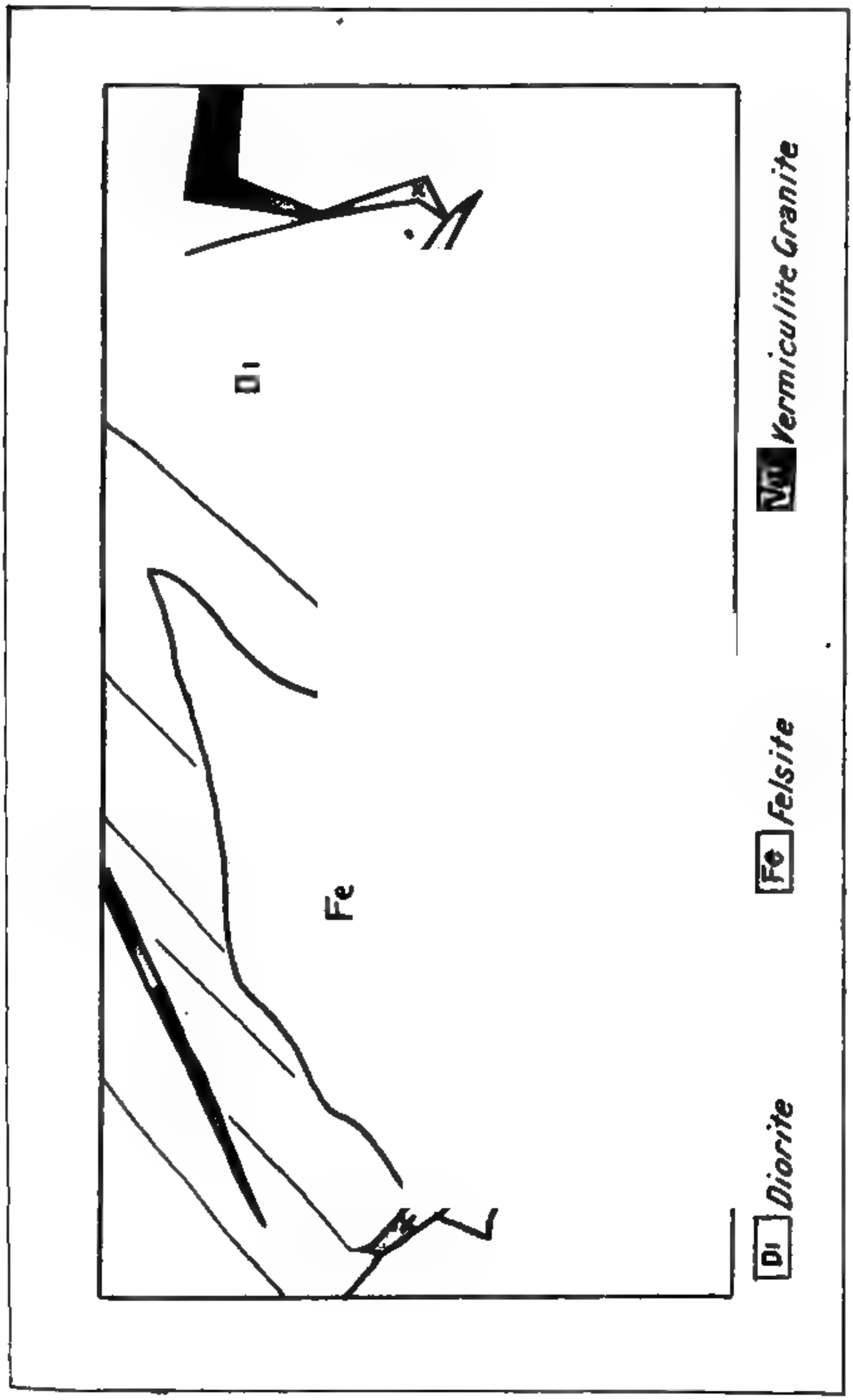

Di
Fe
Vm Vermiculite Granite
Fe Felsite
Di Diorite

PLATE 15.

a

SECTION IN RAILWAY CUTTING (G).

The diorite (Di.) has penetrated a fault in a large inclusion of felsite (Fe.). The faulting took place at an angle with the plane of section, and the upper portion (*a*) of the felsite has moved forward over the lower portion (*b*).

Scale: 1 inch = 18 inches.

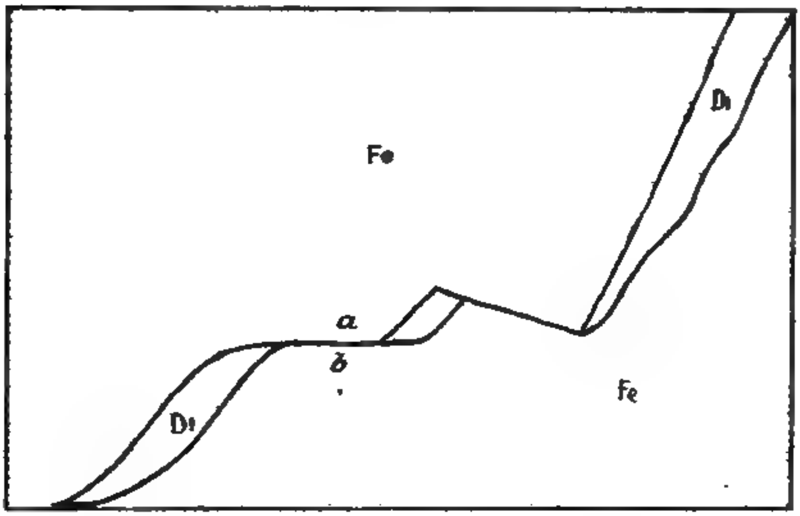
b

SECTION IN RAILWAY CUTTING (G).

The section represents a vein of (*c*) vermiculite granite—marked Gr.—in the diorite (D). The contact of the granite and the diorite is sharply defined, and the junction of the two veins well shown. In the branch vein trending to the left the granite changes gradually to aplite (Ap.) and vermiculite pegmatite, the aplite being near the walls and the pegmatite along the centre.

Scale; 1 inch = $1\frac{1}{2}$ inches.

(*a*)



Di *Diorite* Fe *Felsite*

(*b*)

Di *Diorite* Gr *Granite* Ap *Aplite*

PLATE 16.

Section in Railway Cutting (G).

In this section a mass of quartz-felsite (Q. Fe.) has been faulted, and the resulting fissure has been filled with a friction breccia.

Diorite (Di.) was then forced through the line of fault, forming small subsidiary horizontal offshoots in the quartz-felsite, and leaving the breccia on the footwall.

Subsequently a vein of fine-grained (*b*) or (*c*) granite—marked Gr. in the section—has formed across the diorite and the older rocks, the final stage being the simple dislocation of the formations, along the plane of which, and as the result of expansion and contraction, movements may now be taking place. On either side of this joint plane the rocks are compact and well cemented together.

Scale: 1 inch = 5 feet.

Plate 16

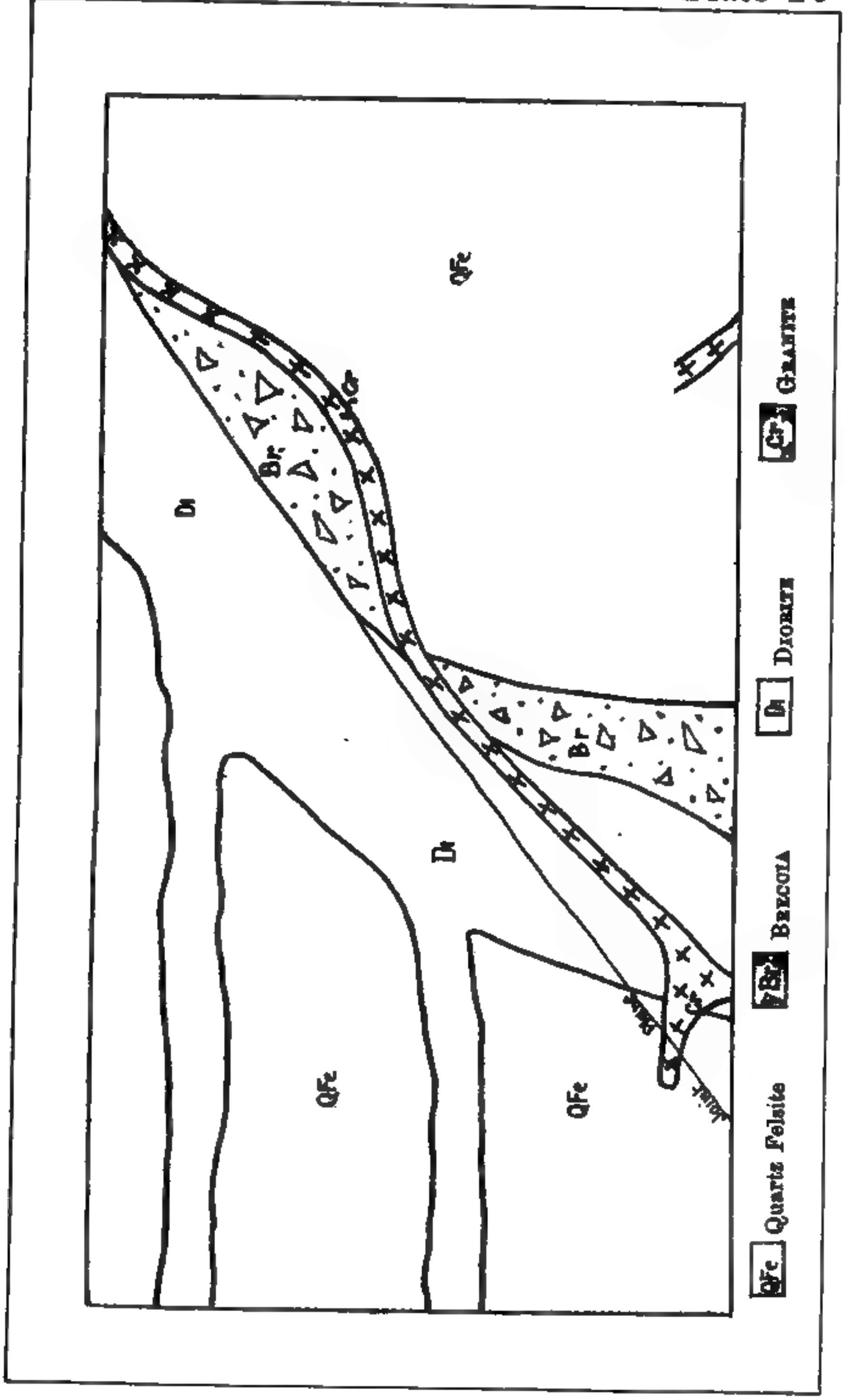

QFe
Di
Br
Gr
QFe
Di
Br
QFe
QFe
Dyke
Joint
QFe Quartz Felsite
Br Breccia
Di Diorite
Gr Granite

PLATE 17.

a

Section in Railway Cutting (G).

The diorite in this section contains a vein of (*b*) vermiculite granite—marked Gr.—across both of which some leaders of (*c*) aplite and micro-pegmatite have been formed. The section is in some respects similar to the one shown on Plate 13, Fig. (A), but in the latter biotite is present.

Scale: 1 inch = 12 inches.

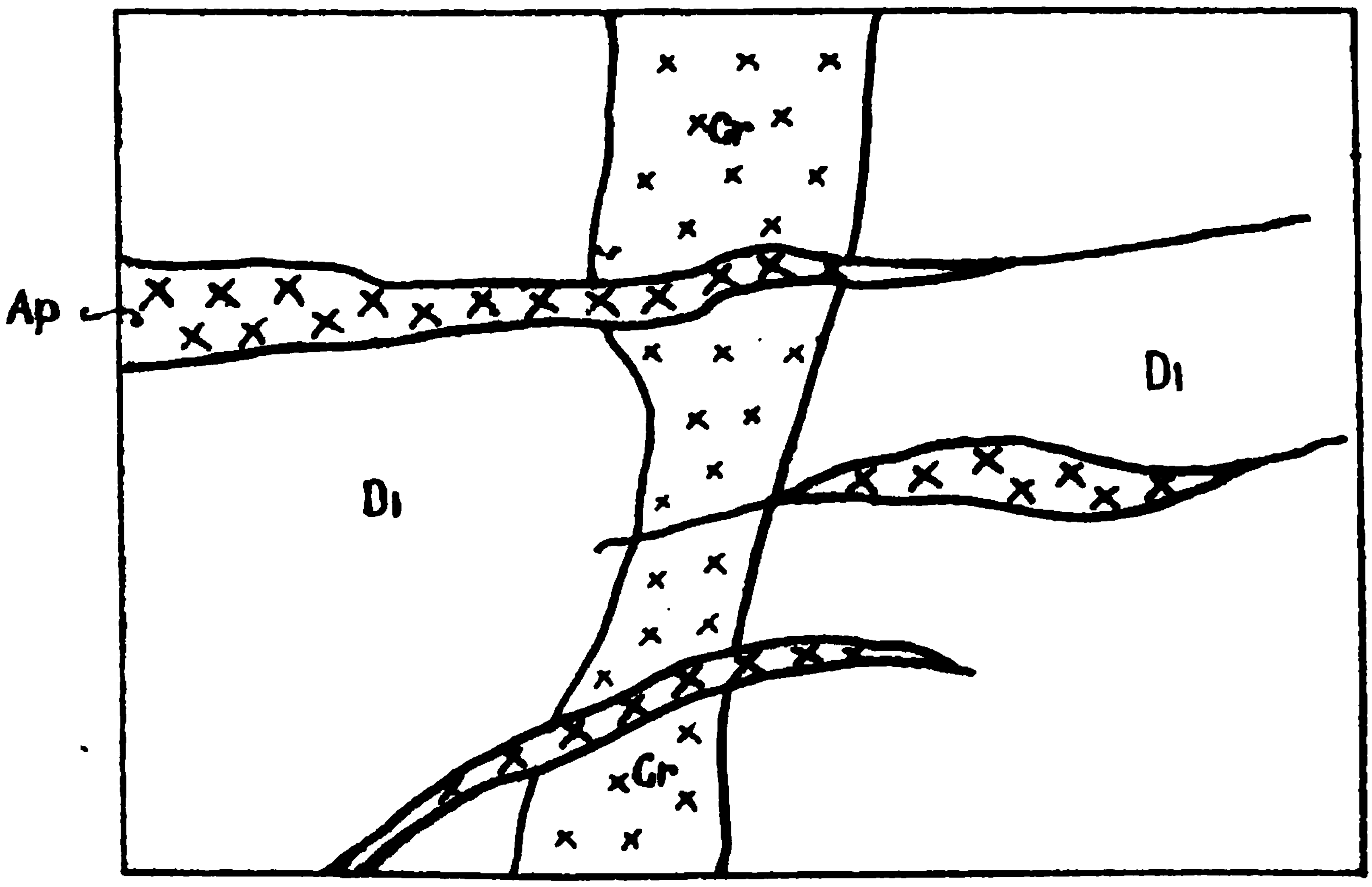
b

Section in Railway Cutting (G).

A vein of (*c*) aplite has formed across both diorite and the quartz-felsite. The aplite is fine-grained, but occasionally large flakes of vermiculite mica are to be seen in it. The vein is wide in the diorite, and gradually pinches out in the quartz-felsite. The gradual tapering of the walls of the vein indicate the diorite and quartz-felsite to have the same degree of plasticity at the time the fissure was opened across them.

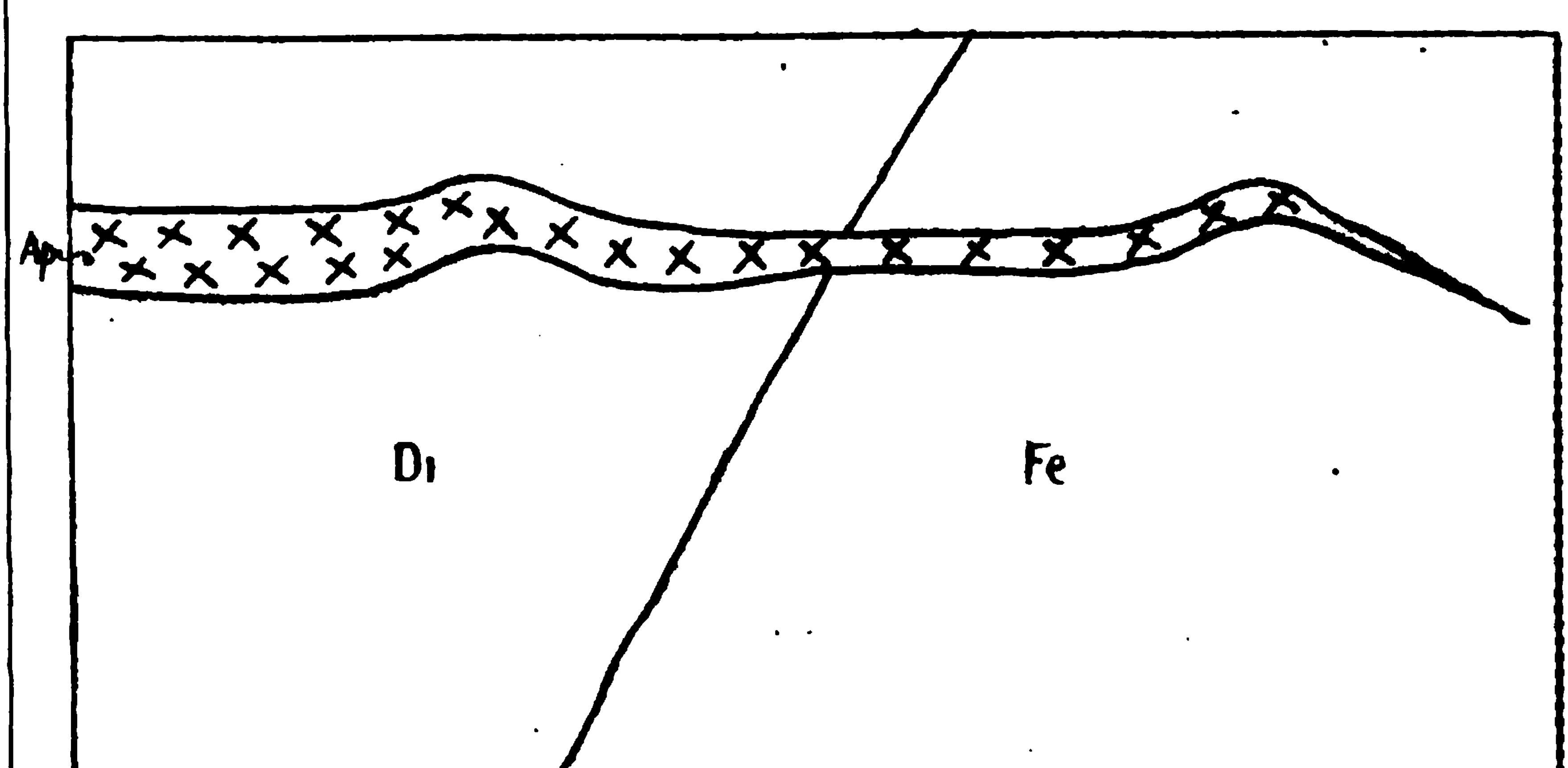
Scale: 1 inch = 2 feet.

(*a*)



Di DIORITE Gr GRANITE APLITE &c.

(*b*)



Di DIORITE Fe FELSITE Ap APLITE

PLATE 18.

Section in Railway Cutting (G).

In the diorite a fissure has been opened, and then filled with a vermiculite granite. The section illustrates an apparent dislocation of the granite vein, but the faulting is only apparently so, the diorite being disturbed and the fissure produced before the granite came into existence. The section indicates that the diorite was sufficiently plastic to allow some portions to be extended without fracture—otherwise such a section would be impossible. The section is not uniformly to scale, but it shows all the salient points.

The same effect appears to have taken place in the quartz-felsite as well as in the diorite shown in Fig. *b*, Plate 17.

Scale: 1 inch = 14 inches (approx.).

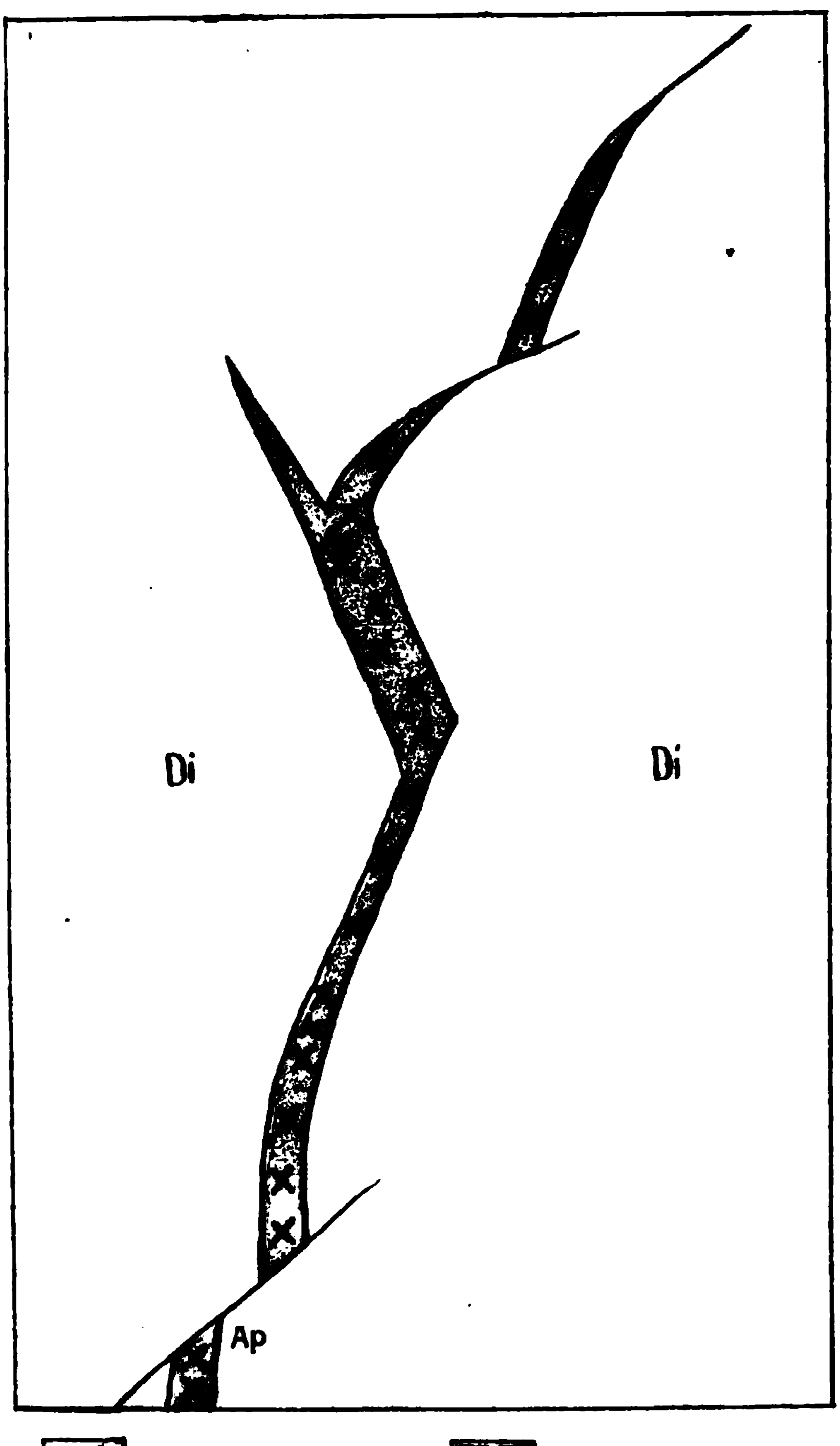

Di
Di
Ap
Di Diorite
Ap Aplite

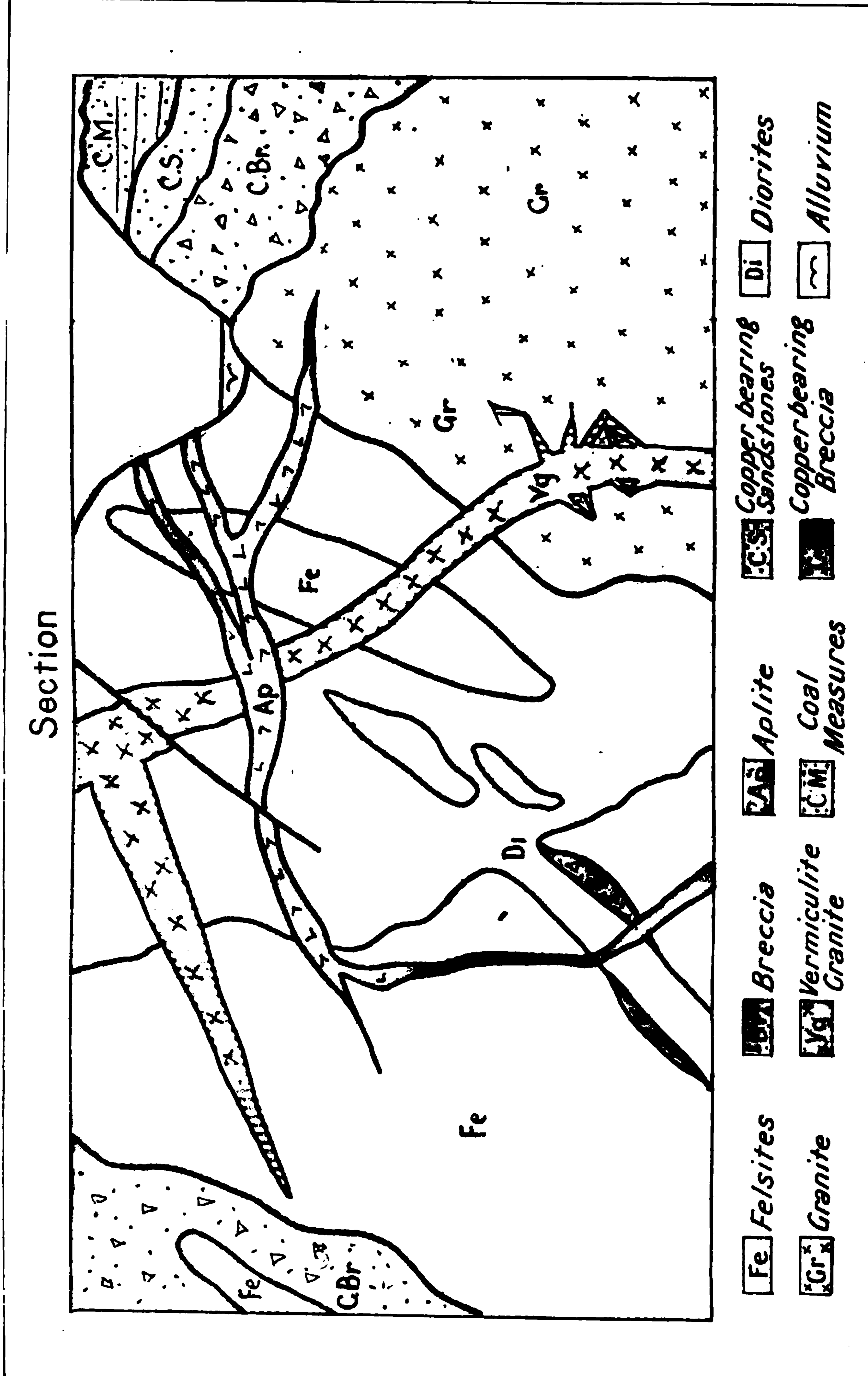
PLATE 19.

Diagrammatic Section.

This illustration is a key or diagrammatic section showing the relation of the systems of rocks to one another at Moonmera.

The granite and syenite (Gr.) and felsites (Fe.) are the oldest rocks, the relation to one another not being known. Faults in the felsites have been formed, and in this a breccia (Br.) has accumulated. Another breccia (C. Br.), copper-bearing, and very massive, has formed above the granite. The diorite (Di.) dykes penetrate the felsites and disturb the breccia, but their intrusion of the old (*a*) granite and syenite has not yet been observed. The intrusion of the felsites by diorite has resulted in portions of the former rock being detached and included in the latter.

Since the diorite intrusions some veins of vermiculite (*b*) granite—marked Vg.—have come into existence in the massive (*a*) granite and syenite, and in the diorite and felsites. Veins of (*c*) aplite and pegmatite—marked Ap.—have formed across the (*b*) granite veins and the older rocks, and then were faulted. The copper-bearing breccia and granite have been denuded in places, resulting in the accumulation of a surface deposit of irregular copper-bearing sandstone (C. S.), and on which the Coal-Measure rocks (C. M.) have been deposited. Weathering of the Coal Measures above, and of the granite, syenite, diorite, felsites, and breccia below, have then taken place, and is in progress at the present time, while alluvial deposits containing gold have been concentrated in the watercourses leading down from the high country.


Section
C.M.
C.S.
C.Br.
Gr
Fe
Ap
Vg
Di
Fe Felsites
C.Br. Breccia
Ap Aplite
C.S. Copper bearing Sandstones
Di Diorites
Gr Granite
Vg Vermiculite Granite
C.M. Coal Measures
Copper bearing Breccia
Alluvium

Queensland.

DEPARTMENT OF MINES.

Geological Survey of Queensland.

PUBLICATION No. 196.

RECORDS.—No. 2,

WITH OTHER NOTES.

(FIVE PLATES).

By B. DUNSTAN.
ACTING GOVERNMENT GEOLOGIST.

CONTENTS:

BRISBANE:
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1905.

I.—GOLD DEPOSITS NEAR MOUNT UBI, WEST OF THE BLACKALL RANGE.

(PLATE 1.)

Many years ago, gold was found in small quantities close to Mount Ubi, and in other localities near the Mary River, west of the Blackall Range; but new life has been infused into the work of prospecting by recent developments, and a number of men are now vigorously searching for gold-bearing veins and alluvial deposits. An examination by the writer was made of the localities around Walli Creek and Chinaman's Creek, two tributaries of the Mary River, situated about 20 miles in a direct line westerly from Nambour, a station on the Brisbane-Gympie Railway Line, and about 25 miles south-westerly from Eumundi.

The country passed over in going to the field from Eumundi is mostly granite until Belli Creek is reached, where slate makes its appearance. The slate continues to Mount Ubi Station, near Tamlyn Creek, and on to Walli and Chinaman's Creeks, where granite reappears with diorite, both forming intrusions in the slate.

At Walli Creek, the site of some recent mining operations, syenite and diorite form a coarse breccia, the syenite occurring as a dyke in the larger mass of diorite, and including in itself fragments of the diorite. Polished sections of the breccia show it to be an attractive-looking building stone, the syenite being coarse in texture and mottled black and white, the fragments of the diorite being about two inches in diameter, of a bluish-black colour, and fine in texture. The rock is compact, free from decomposition, takes a fine polish, and could be obtained in large blocks.

Ottrelite slate is stated to occur *in situ* near the workings which have been sunk in prospecting for gold on Walli Creek. Fragments of the rock were picked up on the surface near one of the shafts, but its exact position could not be determined. Probably it occurs close to the junction of the slate with the syenite.

Quartz reefs, large and small, have been formed where the diorite, granite, and syenite are in contact with one another, and close to where they together are in contact with the slates. The reefs or veins which are gold-bearing, however, are very small, frequently narrowing to an inch in thickness and occasionally disappearing completely. They yield good prospects, but the syenite, granite, and diorite forming the walls are so hard, and the cost of mining consequently so great, that the yields of gold from such small veins would require to be several ounces to the ton to make the working of them profitable.

Other reefs exist in the neighbourhood, which could not be examined at the time; but they are said to be bold, strong reefs, sometimes four feet in thickness, but containing only traces of gold.

On Walli Creek, about two miles above its junction with the Mary River, three quartz veins have been prospected by Messrs. Booker and party, the positions of the various workings being indicated respectively on the accompanying plan (Plate 1) by the letters A, B, C, D, and E. At the position marked A, situated low down on the side of the hill and close to the creek, the country rocks are slate and syenite, between which there is a vein of quartz. The outcrop of the vein is exposed in the bank of the creek, and appears to strike north and south, with an underlie of about 60 degrees from the vertical, and having a general thickness of a few inches, but enlarged in one place to eight inches. The vein was searched for a short distance away from the outcrop in a shaft 28 feet deep, but it was not found, probably pinching out altogether.

Further up the bank of the creek, at the junction marked B, a trial hole and trench have been sunk in granite, exposing a quartz vein varying from an inch to six inches in thickness, and containing traces of gold, and having an underlie to the east-south-east at about an angle of 20 degrees from the vertical. Nothing was observed to encourage further prospecting on the vein.

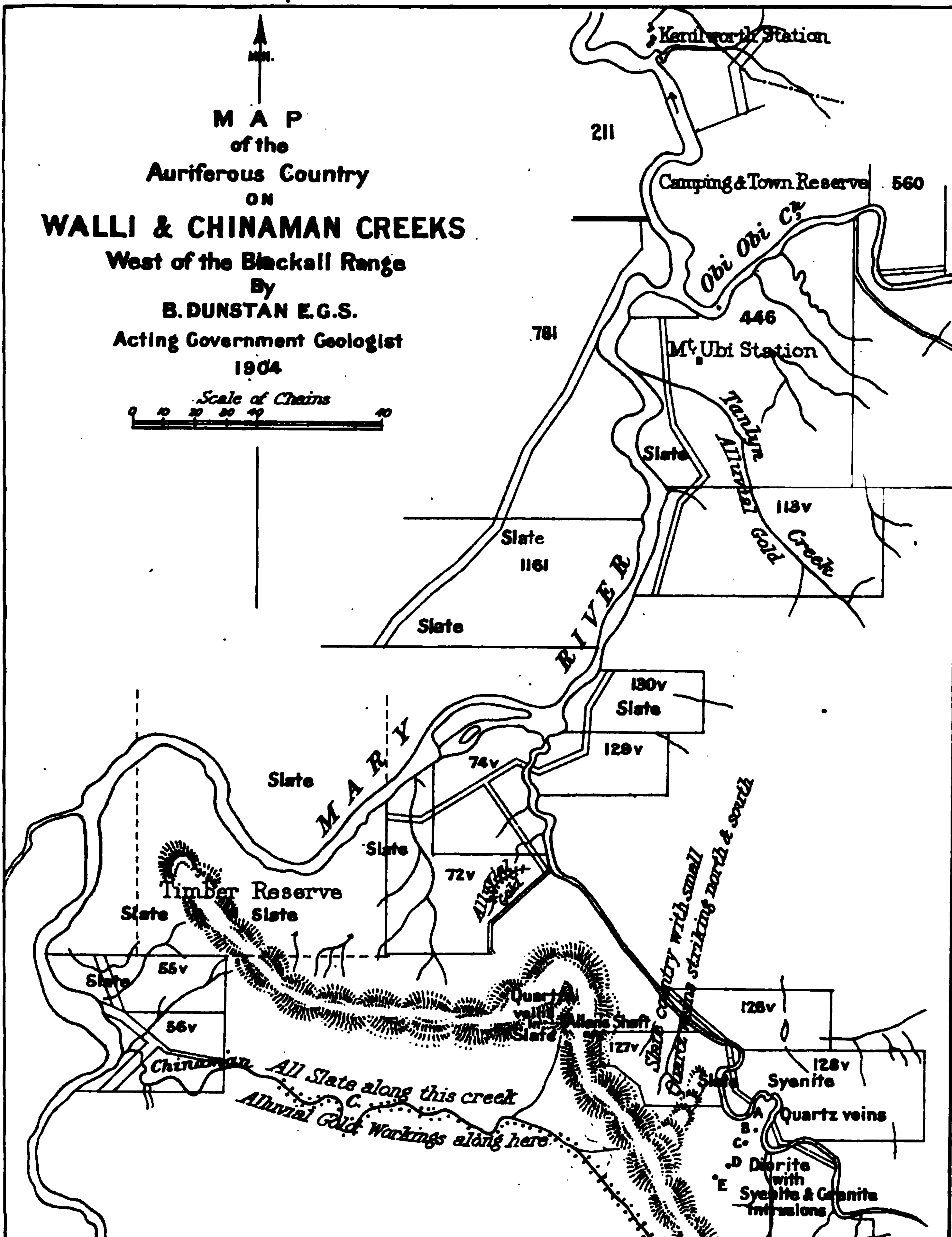
At the position marked C on the plan another excavation has been made, but the workings have fallen in, and have not been reopened.

A shaft was sunk at the place marked D, to a depth of 16 feet, but the vein expected to be found was not discovered, evidently pinching out just below the surface close to the position marked E, where the outcrop occurs. At E, another shaft on the hillside has been sunk in diorite to a depth of 18 feet, but without meeting the vein exposed on the surface. It is here that the syenite-diorite breccia occurs, mentioned above as being a fine ornamental building stone.

Close to the east side of the shaft at E, are other workings. They have exposed the vein which was once considered sufficiently encouraging to warrant this shaft being sunk, but with the results above stated. Copper carbonates occur in traces in this vein.

At Allan's mine, situated on the top of Allan's Ridge (*see* accompanying plan), about a mile north-east from Booker's workings, the country is slate alternating with subangular slate conglomerate, neither granite nor syenite being met with in the mine workings. A few hundred yards south of the mine, however, there is an outcrop of what appears to be a decomposed granitic rock, which, at some considerable depth below the surface, might be in contact with the veins which are known to occur here.

Five veins are exposed on the surface at this mine; all are very small, have a north and south strike, and are nearly vertical. No. 1 Vein has been penetrated in a tunnel driven to a distance of 76 feet, being met with at 66 feet. The vein is about four inches thick, with about three inches of a clay casing, and underlies at about an angle


MAP
of the
Auriferous Country
ON
WALLI & CHINAMAN CREEKS
West of the Blackall Range
By
B. DUNSTAN F.G.S.
Acting Government Geologist
1904
Scale of Chains
0 10 20 30 40 80
Kenilworth Station
211
Camping & Town Reserve
560
Obi Obi Ck
446
Mt Ubi Station
781
Tanlyn Alluvial Gold Creek
Slate
113v
1161
MARY RIVER
130v
129v
74v
72v
Timber Reserve
55v
56v
Chinaman
All Slate along this creek
Alluvial Gold Workings along here
Quartz veins in Slate
Allen's Shaft
127v
126v
128v
Slate country with small Quartz veins striking north & south
Syenite
Quartz veins
Diorite with Syenite & Granite Intrusions
96v
140v
117v

of 10 degrees from the vertical. It is said to contain gold, but none of the stone has been taken out for trial. The tunnel was continued 10 feet beyond No. 1 Vein with the object of striking No. 2 Vein, but has not been driven far enough, the distance between No. 1 and No. 2 Veins on the surface being 20 feet.

No. 3 Vein, 20 feet away from No. 2, varies from two to seven inches in thickness, with an average of four inches. It was worked from the surface to a depth of 15 feet, and several tons of stone were removed, but the work ceased, and the mine is now abandoned and the workings fallen in.

No. 4 Vein, 15 feet away from No. 3, has been worked by a vertical shaft to a depth of 112 feet. The vein was discovered accidentally about eight feet from the surface, has an average thickness of five inches, but varies from half an inch to 15 inches. It is gold-bearing from top to bottom, and two tons, specially tested to prove its value, yielded over two ounces of gold to the ton. This certainly is the most promising vein on the field.

No. 5 Vein has been exposed in a shallow shaft about 40 feet north-west of the shaft on No. 4 Vein. It is about five inches thick in one place, but in a distance of a few feet it pinches to two inches, with several inches of a clay casing. Good prospects can be obtained from the stone by crushing and panning off in a dish.

The alluvial deposits are mostly confined to Chinaman's Creek, although gold was found many years ago at Tamlyn Creek and in one of the watercourses leading into Walli Creek. (*See* plan.) The Chinaman's Creek alluvial deposits, up to the time of the inspection, have only been prospected in a desultory manner, and little information could be gleaned as to the results which were obtained by the miners; but from the more recent operations of the Mount Ubi Gold Mining Syndicate, it would seem that while individual prospecting does not pay, the yields are satisfactory when the work is conducted systematically and on a large scale.

On Allan's Ridge, dividing Walli Creek from the heads of Chinaman's Creek, the veins and leaders are no doubt the source of the gold found in the alluvial deposits, as the rock pebbles and fragments forming the "wash" are identical with the rocks found on the ridge *in situ*.

It has been supposed that mining operations would be more successful if the alluvial gold were traced to the veins from which it has been shed, as the gold would be found to be more concentrated in the veins than in the alluvial deposits. While this might be so, it is more probable that the gold, shed from the numerous small veins and leaders which would not pay to work on Allan's Ridge, only becomes sufficiently concentrated to make the working of it practicable when it is washed into the alluvial deposits of the creek below.

2nd September, 1904.

II.—THE IRONSTONE OF MOUNT LUCY, CHILLAGOE DISTRICT.

(PLATES 2 AND 3.)

Mount Lucy is one of several prominent hills around Almaden, a station on the Chillagoe Railway Line, and has received attention at various times because of the large deposits of ironstone which are known to occur on it. Quite recently it was prospected by a miner for wolfram, who mistook the ironstone for this mineral, which it peculiarly resembles in some of its characters. The tests which have been applied, however, show that it does not even contain traces of this mineral.

Mount Lucy is situated about three miles westerly from Almaden, and is close to the coach road to Georgetown. Between Mount Lucy and Almaden, the hills are all composed of a hornblende-biotite granite containing aplite dykes, quartz leaders, and small irregular quartz masses. Further west of Mount Lucy the granite does not appear on the surface, the rocks exposed being shales, calcareous sandstones, and altered limestones. To the south and north, the prevailing rock is granite.

At the base of the mount, both on the eastern and southern sides, granite is exposed, and near the southern extremity the same rock rises up to within 50 feet of the top. From the latter position the granite has a northerly slope, and is further exposed in the gap between the two peaks (shown in Fig. 1, Plate 2), then sinks below the garnet rock forming the northern end. On the western side the granite is flanked by chert and quartzite, which has been formed, by alteration, from limestone.

From the occurrence of rocks, which are not ironstone, on all sides and on some parts of the top of Mount Lucy, it is clearly shown that ironstone forms a very small portion of its bulk.

The longitudinal section (Fig. 1, Plate 2) shows the position of the granite, the garnet-rock, and the ironstone capping: while the cross section (Fig. 2, Plate 2) showing the rock structures across the lower of the two peaks on the hill, indicates the granite to be the main rock, between which and the chert and quartzite on the western side, a mass of garnet-rock has been formed.

The outcrops of garnet-rock on the hill are partly decomposed, but some portions, which are unaltered, on examination prove to be the garnet variety, Andradite. The garnet-rock has become disjointed in many places, and the cracks have been filled with silica, while much

MT LUCY SECTIONS

Fig. 1

Longitudinal Section

Showing the (1) Granite, (2) the Sedimentary Rocks, (3) the Garnet Rock & (4) the Ironstone Cap.

Length of Section about 400 feet. Height of Southern Peak about 150 feet

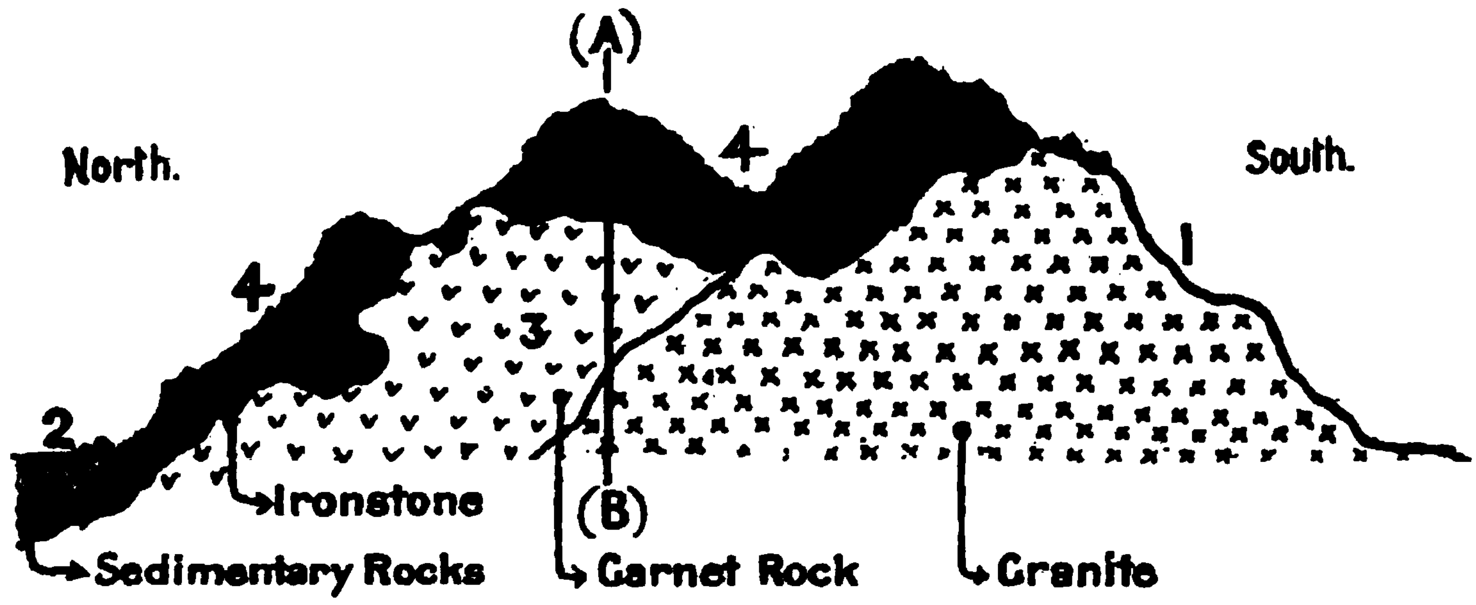
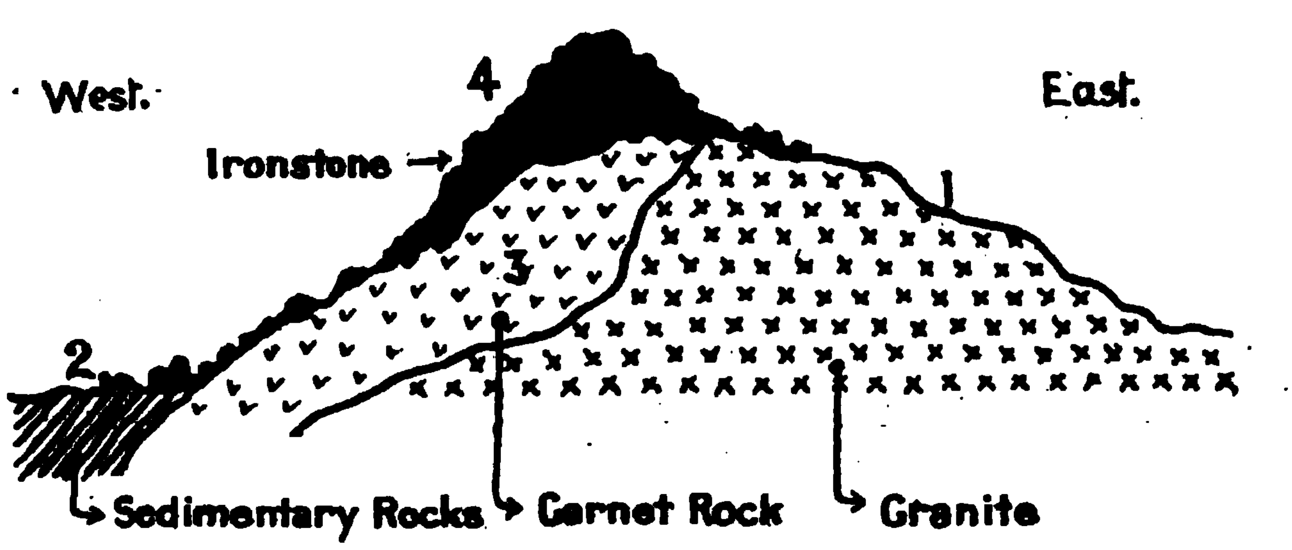


Fig. 2

Cross Section on A B (Fig 1)

(Length of Section about 300 feet)



of the garnet has been changed to magnetite. In this condition the rock has been subjected to exposure and to surface leaching, and the remaining portions of garnet-rock, while retaining their form where crystallised, have been to a great extent converted into friable magnetite.

The occurrence of garnet in association with limestone and granite has previously been referred to by the writer in a description of the rocks at Barmundoo, in the Gladstone district,* and of those at Chillagoe.† Further reference need not, therefore, be made here on their general characters and their relations to one another.

An additional feature, however, has been noticed in the occurrence of the magnetite in chert, the former being a pseudomorph after garnet, the latter resulting from the alteration of limestone. Boulders of this mottled rock occur in the northern end of Mount Lucy, a sketch of one being here reproduced (Fig 1.) They show that where the contact of the limestone with granite takes place, the andradite garnet

Fig. 1.

Boulder of Chert and Garnet.—Mount Lucy.

has formed, frequently as large massive crystals, and that before the alteration of the garnet took place, the limestone was altered to chert and quartzite, the garnet altering to magnetite at a subsequent stage.

The limestones do not outcrop close to the mount, but are exposed about half a mile to the west, where they are somewhat silicified and coarsely crystalline. Closer to the mount the rocks are soft shales and calcareous sandstones, while at its base the cherts are to be found as small rugged outcrops exposed several feet above the surrounding soil.

* Geological and Mineral Features of Diglum Creek, Barmundoo, Gladstone District, &c. By B. D. Brisb.: By Auth., 1901, page 12. (G.S.Q., P. No. 162.) (Bull. No. 16.)

† "Some Chillagoe Geological Notes," in Ann. Prog. Report of the Geol. Surv. for 1900. (G.S.Q., P. No. 156.)

No opportunity has been afforded to thoroughly examine these cherts, so at present no opinion can be formed as to whether they contain any microscopic organisms.

Wollastonite, with chert, forms very conspicuous outcrops, the light colour of the former and the dark colour of the latter being very noticeable features. The wollastonite, in weathering very easily, helps to exaggerate the rugged structure of the chert, which stands out boldly, while the wollastonite is worn down into crevices and hollows. A sketch of this is shown in Fig. 1, Plate 3.

All the data accumulated during the examination indicate the ironstone to be only a shallow deposit, and there is no evidence to show that it forms anything more than a cap to the mountain. The ironstone is, *in situ*, confined to the top, having its highest position at the south end, and gradually falling towards the north end. There is no indication of its extending below the surface, except, perhaps, where the ironstone is close down to the level of the plain on the northern end. (*See* Fig. 1, Plate 2.)

The total length of the mount is about 900 feet, while its width at the base is about 250 feet, the height above the surrounding country being about 150 feet. The average thickness of ironstone is roughly estimated to be 50 feet, its width to be about 50 feet, and its length about 700 feet. With these dimensions the number of tons of ironstone on the cap of Mount Lucy would be about 250,000 tons. Adding to this the large quantity strewn all around the sides of the mount, which amounts to about 100,000 tons, there will be a total of 350,000 tons, a fair estimate of the quantity of ironstone actually in sight.

The mineralogical characters of the ironstone show it to be between magnetite and hematite. Its crystalline form is that of magnetite, while in colour and streak it resembles hematite. Some of the crystals may be isomorphous after garnet, but there is no doubt that some of the magnetite has been formed without being an alteration product of this mineral.

28th June, 1905.

GEOLOGICAL SURVEY OF QUEENSLAND

MT LUCY M

Fig. 2

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III.—TESTING SAMPLES FOR PROSPECTORS.

Samples of ore are constantly being received by the Geological Survey Office from miners and others who desire to know the commercial value of the minerals they contain, but the conditions to be fulfilled are not generally observed, neither are the samples, except in rare instances, properly prepared for assay.

Minerals and rock specimens requiring simple classification are examined unconditionally, but a stipulation is made that those who require fire assays or chemical analyses of minerals should be prospectors, and also that the samples are from localities which are not well-defined centres of mining development, but rather where the country is being developed after having been abandoned, or where previously no prospecting work has been undertaken.

These conditions are objected to by many, but our desire is simply to assist in the work of mineral discovery, and this object is attained by attending to the requirements of the prospector. When assays are made for buyers and sellers of parcels of ore, or for the purpose of company flotation, the schedule charges are insisted upon. The privilege of obtaining free assays from the Department is no doubt abused to some extent, but this evil might be tolerated in view of the good results which accrue in so many other ways.

There is another condition which most prospectors take exception to at first, but which, nevertheless, is quite in reason—that is, making known the locality from which the samples were obtained. An average of about 10 per cent. of the samples tested give returns which show that the minerals they contain are in payable quantities, the 90 per cent. being of no present commercial value. Of the latter, about 60 per cent. are not even of prospective value, the remaining 30 per cent. possibly being valuable in years to come—when facilities for mining development and for transport become better, and when some of the minerals now worthless will no doubt be found useful in some of the manufacturing industries.

It is also very important that the absolutely valueless mineral deposits—the 60 per cent.—should be recorded to indicate the localities where prospecting work has been futile. It is now known that duplicate assays have been made of minerals from the same locality, separate parcels being sent by different individuals, each of whom, perhaps, was not aware that others had furnished similar samples to be tested. Were particulars supplied regarding the localities, this duplication of assays, and the expense incurred, would be avoided.

Another advantage resulting from the possession of this information would be in enabling advice being given to miners who wish to

further prospect a mineral deposit previously examined. Miners could be given the results of previously made assays and tests of mineral deposits they propose to operate upon, if such have been made, and this might result in encouragement being given to further development, or, on the other hand, might indicate that such work would entail waste of labour and money. It has frequently happened that a party of miners, in reopening an abandoned mine, would not have started operations had they known beforehand the result of assays made for those who previously worked the mine.

The preparation of samples for assay and for mineral classification is quite simple, and should hardly need a description. Nevertheless, parcels of stone are frequently received which consist perhaps of a couple of pieces, and which cannot be considered average samples. For the *determination or classification* of any mineral species, good clean pieces are desired, and the quantity should not be too small. In the *estimation of quantities*, such as the percentage of copper or tin, or the number of ounces of gold or silver per ton, it is necessary to carefully prepare the samples. Many will break off a piece of stone from a lode and from that expect a result indicating the average yield of the whole mass, and fail to see that in such a test rich stone may be overlooked. On the other hand, the specimen might give a rich return, and will perhaps result in money being spent in developing the deposit of mineral, after which it might be found that the bulk of the stone is either barren or too poor to pay. The man who supplies the funds for carrying on operations might think the prospector had deceived him as to the quality of the stone, or both might think the stone was not properly tested in the laboratory, and put the blame on the assayer.

The better method of sampling is to take stone from all exposed places on the lode, which must then be crushed and mixed, and afterwards quartered. One quarter is then more finely crushed and again mixed and quartered, the operation being repeated until the bulk is reduced sufficiently to make a small finely-crushed sample weighing two or three pounds. When this is not practicable, very small pieces—say, fifteen to the ounce—should be chipped off all exposed places, from which a sample is taken after finely crushing and mixing. This will give a fairly satisfactory result, although not so accurate as the former method. It would also be as well to include a large chip of the mineral as a guide to its classification.

Attention should also be given to the forwarding of samples. They should have some distinguishing mark, and this should be referred to in the letter of advice. Many samples received are without marks, which causes confusion, and the greatest care has to be exercised in identifying post-marks, or in comparing handwriting, in order to avoid samples from one individual being mistaken for those sent by another.

23rd January, 1905.

IV.—MONAZITE IN QUEENSLAND.

For some time past monazite has been known to occur in the beach sands on the coast of Queensland, and numerous samples have been sent to the Geological Survey Office for the examination of their monazitic contents.

Many years ago the beach sands near the mouth of the Tweed River were prospected for gold, and in a small quantity of the sand purchased by this office from Mr. Dwyer there were detected platinum and osmiridium, a concentrated sample of which yielded on assay 26.12 per cent. of platinum and 40.02 per cent. of osmiridium. In 1903 another sample, purchased from the same miner, was found to contain a monazite-like mineral, alluvial gold, 2.16 per cent. of platinum, and 1.61 per cent. of osmiridium. During March and May, 1904, other samples of beach sand from near the mouth of the Tweed were submitted for examination, the first one received with the intimation that it was thought to contain monazite. In May an inspection of the beach sands north of the entrance to the Tweed River was made by Mr. Ball, who obtained samples in which the Government Analyst detected the presence of 4.3 per cent. of earths of the cerium group (calculated as oxides and including 0.4 per cent. of thoria). Subsequently information was received that the beach miners were obtaining tinstone, a concentrated sample of which yielded 54 per cent. of tin. This, on a later inspection, was confirmed by Mr. Ball, whose report has already been published.*

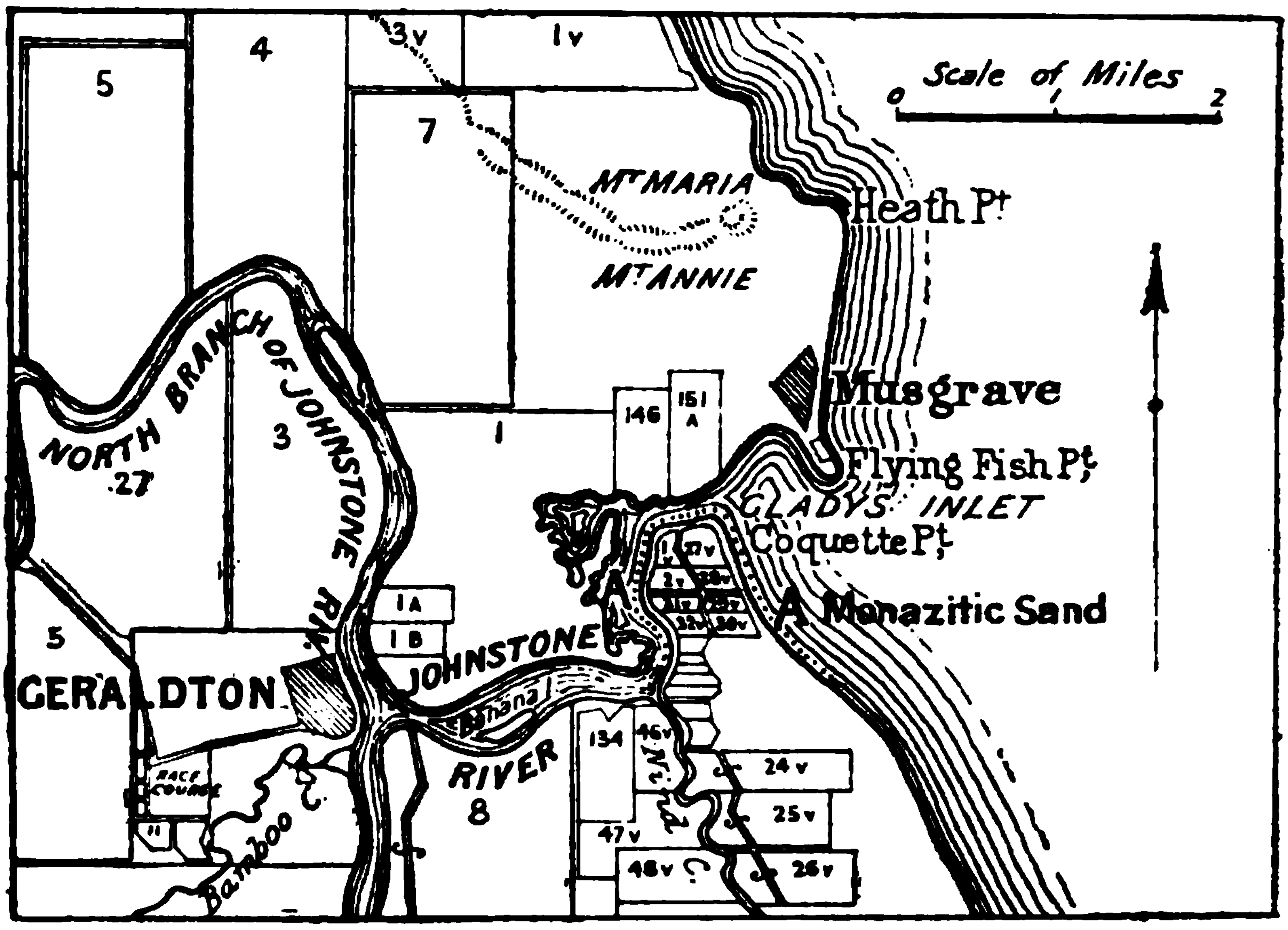
The presence of the monazitic sands at the Tweed has resulted in other parts of the coast being prospected, and a bulk sample from the mouth of the Johnstone River, obtained through Dr. MacDonald, of Geraldton, was forwarded by the Department of Mines during March, 1904, to the Imperial Institute in London for examination.

The locality from which this sample was taken, according to Mr.

* Q.G.M. Jour. Feb., Vol. vi., 1905. Pp. 62-67.

John Cameron, is inside the entrance to the river on the south side, and is shown on the accompanying sketch plan. Mr. Chap-

Fig. 2.



PLAN SHOWING POSITION OF MONAZITIC SANDS, JOHNSTONE RIVER.

(Monazitic Deposits along dotted line from A to A.)

man, who has been examining the beach deposits in the neighbourhood of the Johnstone River, states that there are no iron-bearing sands on the beach on the north side of the river, and he is of opinion that the ocean beach on the south side of the entrance would yield more heavy minerals than the locality from which the analysed sample was taken.

This concentrated material was then analysed in the Scientific and Technical Department of the Imperial Institute, and gave the following result:—

Silica, SiO_2	7.59 per cent.
Titanium oxide, TiO_2	44.59 ,,
Zirconium oxide, ZrO_2	1.06 ,,
Thorium oxide (thoria), ThO_2	0.23 ,,
Alumina, Al_2O_3	1.46 ,,
Yttria, Y_2O_3	0.10 ,,
Ferric oxide, Fe_2O_3	1.24 ,,
Ferrous oxide, FeO	36.38 ,,
Manganous oxide, MnO	2.79 ,,
Copper oxide, CuO	0.05 ,,
Lime, CaO	0.79 ,,
Magnesia, MgO	1.16 ,,
Cerous oxide, CeO	0.46 ,,
Phosphoric acid, P_2O_5	0.41 ,,
Niobic oxide, Nb_2O_5 / Tantalic oxide, Ta_2O_5	0.78 ,,
Moisture	0.8 ,,

These results indicated the presence of the minerals ilmenite, quartz, garnet, zircon, magnetite, monazite, and possibly tantalite in the "concentrate," and this was confirmed by microscopical examination. The proximate composition of the concentrated mineral may, therefore, be taken as—

Ilmenite (Fe, Mn, Mg)O, TiO_2	84.0 per cent.
Magnetite, Fe_3O_4	1.8 „
Zircon, ZrO_2, SiO_2	1.4 „
Quartz, SiO^2	4.4 „
Garnet and other silicates containing alumina, lime and magnesia	5.0 „
Monazite*	1.2 „
Tantalite	0.9 „
Moisture	0.8 „

* A portion of the thoria may be present as thorite (thorium silicate).

The only constituents of the sand likely to be of immediate commercial value are the oxides of thorium and cerium. The amount of thoria present in the "concentrate" is only 0.23 per cent., and in the crude mineral 0.05 per cent., and the proportion of cerium oxide 0.46 per cent. in the "concentrate" and 0.10 per cent. in the original sand.

Material as poor in these oxides as the present sample, or even the "concentrates" prepared from it at the Imperial Institute, would probably not prove remunerative to work under present conditions. At the present time the value of the "concentrates" as a source of thoria would probably not exceed £2 10s. per ton, assuming that it would pay to extract thoria from such material.

The percentage of thoria could doubtless be increased by removing the magnetite and ilmenite by magnetic separators, but it would seem hopeless to attempt to compete by these means with the Brazilian monazitic sands, which constitute at present the principal commercial source of thoria; these, in the concentrated form in which they are exported, yield from 5 to 8 per cent. of this oxide. A mineral found in Ceylon, and discovered to be a new mineral (thorianite) by analysis at the Imperial Institute, contains as much as 70 to 80 per cent. of thoria, and therefore is of greater value than any other source of thoria. The quantity available appears, however, to be small.

The percentage of cerium oxide in the Queensland sand is double that of the thorium oxide, but the demand for the former is very limited, since, in the construction of mantles for incandescent gas lighting, only 1 per cent. of ceria is used to about 99 per cent. of thoria.

Titanium oxide is present in the concentrate to the amount of 44.59 per cent., corresponding to 9.27 of the crude sands.

* * * * * * *

The only other constituent of the sand likely to possess commercial value is the tantalum. Recent experiments have shown that this

metal can be used as a filament in electric glow lamps, and such lamps are now on the market. The "concentrate" prepared from the Queensland sand contained, however, only 0.78 of tantalic and niobic oxides, so that it is improbable that this material could be used as a commercial source of tantalum in competition with the other richer tantalum minerals available.

During an examination by the writer, in December, 1904, of the wolfram fields of Northern Queensland, tests were made of a heavy mineral occurring at several localities on the Walsh and Tinaroo Mineral Fields, which the miners thought might be scheelite, but which blowpipe and other tests indicated to be monazite or some mineral closely allied to it. As the mineral in two of the localities occur *in situ*, close attention was paid to its mode of occurrence. The mineral was first pointed out by Mr. MacMahon, a miner, who wanted to know if the heavy brown mineral being found in small quantities with alluvial tin around Fossilbrook was of any value. Later on, the monazite was identified at Bamford, Old Wolfram Camp, Emuford, Ord, and Coolgarra, occurring only in traces on some of the fields, while in others its presence in quantity constituted a serious hindrance to the cleaning of the wolfram associated with it.

The monazite has only been found *in situ* where wolfram deposits pay to work, so probably other richer deposits are known which have been passed over because of the absence or scarcity of wolfram in them.

The miners have thrown it away as worthless because the wolfram dealers, knowing it was not scheelite, have refused, repeatedly, to take it at any price. A wolfram-mining venture in one place failed, and the mine was abandoned, because the supposed scheelite could not be sold, while at another locality a wolfram miner had accumulated a large quantity of it, and, without considering its prospective value in other respects, was pleased to be told, in time, that it was not scheelite, thus saving the expense of dressing, bagging, and forwarding by rail to Cairns.

Later on, further details of the monazite deposits will be given in connection with the report being prepared on the wolfram fields of Queensland, but in the meantime some information concerning it may be here given for the benefit of those interested in the matter.

The colour of the mineral varies from deep reddish-brown, clove-brown, light-brown, to light brownish-yellow, presenting frequently the colour and lustre of "resin" tinstone. It is semi-translucent on the edges and in thin flakes, but otherwise is opaque. The lustre is somewhat resinous on a fractured surface, but is glassy or shining on fresh cleavage faces. It has distinct cleavages in three directions (as well as others not easily recognised), somewhat resembling in appearance the rhombohedral cleavage of calcite.

With a knife blade monazite can be scratched without difficulty; but, being rather brittle, and separating readily into cleavage flakes, some specimens crumble when scratched, and give the impression that the mineral is rather soft.

The specific gravity is high, being 5.04 (equivalent to iron pyrites); and, while this makes it troublesome to separate from the wolfram in the dressing of that mineral, it affords a very ready means of distinguishing it from most other minerals otherwise resembling it.

Topaz, scheelite, and felspar are minerals commonly found with the wolfram, and by the novice may easily be mistaken for monazite. The topaz may be known by its extreme hardness (being scratched with a knife), but otherwise, in rough specimens, particularly in colour, it has been observed to much resemble monazite.

The scheelite, which may be scratched with a knife, is but a little heavier than monazite and sometimes resembles it in colour, but the three distinct cleavages are absent. The felspar, in its colour and cleavage, may be mistaken for monazite, but it has not a resinous lustre; besides, it is so much lighter in weight, and is not so readily scratched with a knife. The blowpipe reactions are also useful tests in distinguishing these four minerals from one another, but the tests cannot be applied by those having no experience in blowpipe work.

The monazite was observed to occur in pure crystalline masses, sometimes several pounds in weight, and also in small cleavable grains. Both forms are irregularly disseminated in quartz, black mica (biotite), and chloritic mica, and are in association with wolfram, molybdenite, scheelite, tinstone, fluorspar, and mispickel. With the exception of wolfram, these associated minerals are only in comparatively small quantities.

The deposits containing the monazite are in granite country, but close to quartz-porphyry and slate. In the granite, and also at the junction of this rock with the porphyry and slate, irregular masses of greisen have been formed from the alteration of the granite, and it is in this, following closely the behaviour of the wolfram, that the monazite deposits are to be found.

The size of the monazite masses and the percentage of the mineral in the greisen lodes, are abnormally high when compared to foreign monazite deposits, and no doubt a large quantity of it could be obtained as a by-product in the mining of wolfram.

The most important foreign monazite deposits are in Brazil and in the State of South Carolina, United States. The Brazilian mines in 1902 produced about 811 tons of monazite sand, having a percentage of from 5 to 8 per cent. of thoria (the substance so valuable in the manufacture of incandescent gas mantles), the total value being

£16,898 19s. 2d., or about £20 16s. per ton. The South Carolina mines in 1903 produced 340 tons of monazite sand, valued at £13,464, or about £35 per ton.

A preliminary analysis of a clean sample of the Queensland monazite yielded 66 per cent. of cerium and other rare earths (Government Analyst). A commercial sample, uncleaned and without any concentration, yielded 2.6 per cent. of thoria, and 56.1 per cent. of oxides of the cerium and yttrium groups (Basil Turner). This sample, if concentrated or picked to obtain clean mineral, would probably yield 3 per cent. of thoria, which at, say, £5 per unit, would show the monazite to be worth £15 per ton. This return certainly warrants further attention being paid to the occurrence of the deposits as an increase of 2 per cent. of the thoria—making 5 per cent.—would be worth about £8 per unit, or about £40 per ton of monazite.

17th May, 1905.

V.—A SOIL SURVEY FOR QUEENSLAND.

The advantages which would result from having a survey made of the soil areas in certain parts of Queensland have been so satisfactorily demonstrated that nothing need be stated here in support of the proposition made that one should be undertaken. Something, however, may be added regarding the carrying out of such a project.

A soil survey, it must be clearly understood, must be very thorough in its work if good results are to be expected of it, and this can only be achieved by its establishment on a proper basis, and by the employment of men having a scientific training.

American practice in this respect has been very successful, and may be taken as a guide for us to follow. There, it has been shown, the work of collecting information is being performed by a staff of men who are closely in touch with a geological and mineral survey, and in some of the States all the specialists in geology, mining, agriculture, &c., comprise the staff of what is termed a geological and natural history survey.

Economy and general utility have been made the basis of the amalgamation, as it was found that information bearing on soils, minerals, rocks, physical features, timbers, &c., could be collected by the one survey party, leaving much of the details to be worked out in the laboratories by the mineralogist, petrologist, palæontologist, chemist, botanist, entomologist, and other specialists.

In our own Geological Survey most of the work of the staff is connected with the mining industry, and the increasing demands made on it in connection with the examination of mines and mining districts leaves no time to devote to work of a more general character. With the proposed soil survey, and the existing geological survey, however, the nucleus of a geological and natural history survey could be established, which in course of time would so develop that the work of its officers would be applied to other industries besides mining and agriculture.

A reference to this subject was made in last year's Progress Report of the Geological Survey,* showing that information should be accumulated about all mineral products which could be utilised for industrial purposes, such as mineral fertilisers, pottery and brick-making material, ornamental and building stones, cement-making material, mineral lubricants, and mineral paints.

26th February, 1905.

* Ann. Rep. Dept. of Mines, 1903, p. 172.

VI.—BORING FOR COAL NEAR TOWNSVILLE.

(PLATE 4.)

An inspection by the writer was made recently of the developments in coal prospecting close to Townsville, on the Northern Railway Line, and while engaged on this work some data was accumulated regarding the position and depths of some of the bores put down many years ago.

In a report on coal near Townsville,* Dr. Jack refers to the existence of coal measures in a railway cutting at Stewart's Creek, 6½ miles from Townsville, on the railway line, in which a small seam of coal was exposed. The analysis of a sample of this coal gave the following results:—

Analysis of Small Coal Seam, Stewart's Creek Railway Cutting.

Volatile matter (including water) ...	53·84	per cent.
Fixed carbon	37·87	„
Ash	8·29	„
	100·00	

The remarks appended show that "the coal is of a remarkably high quality, whether for gas-making or steaming purposes. Should a similar seam be discovered of workable thickness, a great impetus would be given to the manufacturing industries of the North."

In 1888 another report (unpublished) was made by Dr. Jack on the same subject, having special reference to some bores sunk at Stewart's Creek for the purpose of testing the measures containing the small seam of coal referred to above.

The examination made by the writer included an inspection of the various bore sites and the coal-measure outcrops, together with the eruptive rocks in the vicinity, and the opinion was formed that the bores have been put down too close to the eruptive rocks, and that it would have been better to have sunk further north-west, even if the drift, which has been found to be of considerable thickness in the bores, were expected to be deeper before the measures were penetrated.

The rocks exposed on the surface near the railway show that shales and greywackes are interbedded with sheets of basalt and with volcanic tuffs containing impressions of *Glossopteris*, the disturbed conditions which generally prevail indicating that if a coal seam were found it would prove to be unworkable.

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* Geological Observations in the North of Queensland, 1886-7. R.L.J. Brisb.: By Auth., 1887, page 14. (G.S.Q., P. No. 35.)

Two other bores have been put down at Stewart's Creek by the North Queensland Collieries Company, the two bores being 1,000 feet apart. No. 1 North Queensland Collieries Company's bore was sunk in 1903 to a depth of 193 feet by a calyx drill, then continued to 259 feet by a diamond drill. No. 2 North Queensland Collieries Company's bore was sunk in 1904 to a depth of 233 feet by a jumper drill.

At Antil Plains a bore is being sunk in coal measures, but the results, so far, have not been successful.

The following is a list of bores and shafts which have been put down at various times about Stewart's Creek, and their positions are shown on the accompanying plan. (Plate 1.)

STEWART'S CREEK COAL BORES AND SHAFT.

*Twaddles No. 1 Bore—

Position—One chain south of Haswell's Shaft.

Record—89 feet deep in drift. Abandoned.

*Twaddles No. 2 Bore—

Position—At south-west corner of Portion 100.

Record—101 feet in drift. Abandoned.

*Twaddles No. 3 Bore—

Position—At south-east corner of Portion 100.

Record—59 feet in drift, then struck porphyry. Abandoned.

*Twaddles No. 4 Bore—

Position—At the middle of western side of Portion 100.

Record—109 feet in drift, then 39 feet 7 inches in bedded sandstones.

*Simpson and Rodger's Bore—

Position—In Portion 99, 20 chains from northern boundary of Portion 100.

Record—50 feet deep in drift. Abandoned.

*Haswell's Shaft—

Position—Seven chains east of Simpson's Bore.

Record—44 feet deep in drift. Abandoned.

*Townley Coal Company's Bores—

Position—Sunk within a few inches of one another, 30 chains south of Portion 100, on Reserve.

Record of No. 2 Bore—Drift, 26 feet; sandstones and shales, 59 feet; trappean rock, 15 feet; total, 100 feet. Bore abandoned because of an accident.

Record of No. 1 Bore—Drift, 26 feet; sandstones and shales, 58 feet; total, 74 feet.

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* Report (M.S., No. 19) by Dr. R. L. Jack, dated Townsville, 29th May, 1888.

Shallow bore—

Position—In Portion 122v, west of Townley bores, between creek and railway.

Record—In drift: depth, 10 feet (?).

North Queensland Collieries Company's No. 1 Bore—

Position—In Portion 150, south of Portion 8v.

Record—Drift, 78 feet: coal measures, 181 feet (coal traces at 86 feet, coal and shale band at 123 feet, 7-inch coal seam at 123 feet): total, 259 feet.

North Queensland Collieries Company's No. 2 Bore—

Position—1,000 feet south of No. 1 bore.

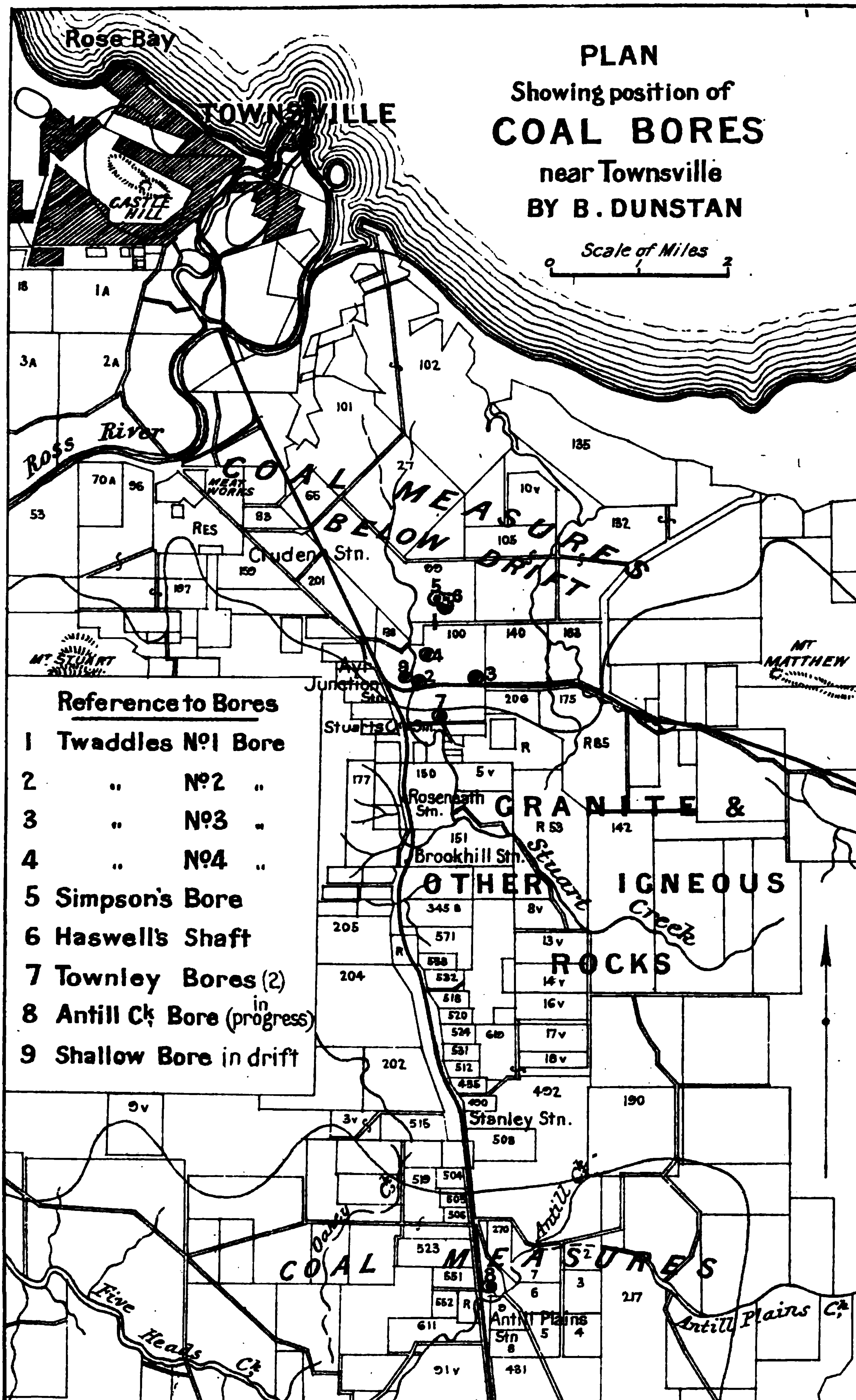
Record—Drift, 33 feet: coal-measure sandstones and shaly sandstones, 200 feet 6 inches; total depth, 233 feet 6 inches.

North Queensland Collieries Company's No. 3 Bore—

Position—Near Antil Plains Railway Station.

Record—Coal-measure sandstones; depth, ?

16th February, 1905.


PLAN
Showing position of
COAL BORES
near Townsville
BY B. DUNSTAN
Scale of Miles
0 1 2
Reference to Bores
1 Twaddles No. 1 Bore
2 " No. 2 "
3 " No. 3 "
4 " No. 4 "
5 Simpson's Bore
6 Haswell's Shaft
7 Townley Bores (2)
8 Antill Ck. Bore (in progress)
9 Shallow Bore in drift
Rose Bay
TOWNSVILLE
CASTLE HILL
Ross River
COAL MEASURES BELOW DRIFT
MEAT WORKS
RES
Cluden Stn.
Mt. STUART
Mt. MATTHEW
Junction Stn.
Stuart's Ck. Stn.
Roseneath Stn.
Brookhill Stn.
GRANITE & OTHER IGNEOUS ROCKS
Stuart Creek
Stanley Stn.
Antill Ck.
Oaky Ck.
COAL MEASURES
Five Heads Ck.
Antill Plains Stn.
Antill Plains Ck.

VII.—THE TESTING OF QUEENSLAND COALS.

The industrial importance of having a series of practical tests made of the numerous varieties of Queensland coals has become so very evident of late that some details of the methods which should be adopted in an investigation might be added to the remark made previously in the Geological Records, No. 1, of 1904.

It may be stated, in the beginning, that we have coals in Queensland which appear to be suitable for every purpose, whether for steam-raising, coke-making, gas-making, smiths' work, or domestic uses.

For steam-raising there are a great number of good coals which can be utilised for general work, some being best adapted for use in locomotive boilers, while others are more suitable for firing marine boilers. Of the latter class, a few have the rare quality of being smokeless, and, therefore, other conditions being favourable, adapted to the requirements of the Admiralty.

Many of the coals are well suited for coke-making, and some of these, with up-to-date plants for washing and coking, would make coke of the finest quality.

In the manufacture of gas for illumination, many of our coals are being used extensively at the present time, and their value in this respect is fairly well known. In the production of gaseous fuel, little is known as to their suitability, and more information on the question is much desired.

The results of numerous tests which have been made from time to time are undoubtedly satisfactory, so far as they go, but no standard tests have been made showing all the qualities of the different classes of coal; and at the present time a consumer of coal has to find out, in the best way he can, which coal suits his particular requirements. For

example, the agent of an English firm desired to introduce a plant for making producer gas for fuel purposes, and wanted particulars as to the merits of the coals on the market. This information could not be supplied, and necessitated the firm making its own inquiries and conducting its own experiments to determine whether the coals which could be obtained answered the purpose.

Such tests should be made officially, and would be for the benefit of that particular firm or any others who desired to introduce some innovation by which the consumption of coal would be encouraged.

If ironworks were established in Queensland, and the respective merits of the coals were required to be known, the desired information could not at present be given except in a general way.

The naval authorities require for their warships a coal possessing certain characteristics. They have made trials of some of our coals, and are anxious to make further experiments, and for that purpose want Queensland coal supplied to them. Such experiments and tests should also be tried here according to some standard, the results of which would help the Admiralty in avoiding the trial of inferior coals, and would be of considerable assistance to those who might desire to open up a coal trade to countries outside Australia.

The oversea traffic in Queensland coal is somewhat limited, and vessels have not taken kindly to the class of coals which here have been offered to them. It is known that some firms condemn Queensland coal generally because of the failure of shipments from one locality, but it should be pointed out to the shipper that there are to be obtained several kinds of Queensland coal, some of which would be bound to answer their purpose, and were the standard tests carried out we would be able to show beyond doubt that no necessity arises for their going outside Queensland for their requirements.

The Railway Department use large quantities of coal on their locomotives and in their workshops, and information as to the quality of the coal on the different fields would indicate those which would best suit them.

The necessity of making standard tests, however, would not arise were the coal supplies of Queensland limited in quantity, but there are ready for development immense reserves of coal in both the Southern and Central districts, and recent discoveries show that the Northern district will possibly be a producer of coal, even of anthracite, in the future.

The methods to adopt in testing would take into consideration all the qualities of a coal, so as to determine their fitness for stationary, marine, and locomotive boilers, for coke-making and for smelting furnaces, for use in smiths' forges and for domestic purposes, and for the making of gas for fuel and for illumination.

The examination should include the following tests:—

Ultimate chemical analysis.
Approximate chemical analysis.
Estimation of calorific values by formulæ.
Tests in a standard calorimeter.
Calorimeter tests in a standard boiler.
Trials in a locomotive engine.
Trials in a marine engine.
Trials showing behaviour in transit.
Trials showing liability, or otherwise, to spontaneous combustion.
Trials in a coking-oven.
Trials in a gas retort.
Trials in a gas producer.

The trials and tests should be under the control of a number of professional men, each to be a specialist thoroughly acquainted with some branch of the work, and whose experience, personal supervision, and interest in the work would guarantee the tests being carried out faithfully and systematically.

The constitution of such a body of professional men must necessarily be composed of an analytical chemist to undertake the chemical analyses and the laboratory calorimeter work, and marine and locomotive engineers to supervise the boiler tests. The coking and the gas experiments would be conducted by men expert in those branches, while a geologist would be held responsible for the production of the bulk samples from the mines, would define the position and character of the seams of coal from which the samples would be obtained, and also furnish other geological data concerning the probable supply of coal on the fields.

The above would form a coal-testing board on the lines of many such other boards which have accomplished similar work in other countries, all the members of which, with one or two exceptions, could be selected from officers in the Government service.

6th February, 1905.

VIII.—MINERAL NOTES.

AGATE AT LITTLE RIVER.

Little River is a small stream which is crossed on the coach route between Georgetown and Croydon, and the position of the agate deposits examined by the writer is about 30 miles easterly from Croydon.

The surface rocks are principally Desert Sandstone (?) and a partly decomposed basalt, the latter evidently being older than the former, as the agates which have formed in the basalt occur as pebbles in the sandstone.

The basalt is traversed by quartz veins evidently formed at the same time as the vesicles in the basalt, which are filled with agate, and the abundance of agate pebbles on the surface of the decomposed basalt indicates that a large area of this rock has been subjected to the infiltration of silica. The Desert Sandstone (?) is in part changed to "billy" (the surface quartzite found so commonly in Queensland), and nearly all the hills around are capped with it. Below the beds of sandstones and the flows of basalt the rocks are felsites.

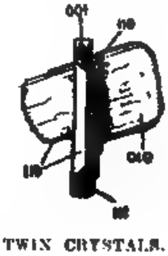
The agates are not of large size, four inches being about the maximum in diameter. The banding and colouring are beautiful in some of the specimens selected for examination, but in the larger sizes the centre is usually crystalline quartz, with calcite also occasionally present. Some specimens, sectioned and polished, are shown in the Geological Survey Museum, Brisbane, and may be taken as types of Little River agates.

At the Percy River, about 60 miles south of Georgetown, more extensive deposits of agates are known; here the nodules of agates are said to be much larger, and in even greater abundance.

GYPSUM TWIN CRYSTALS AT EUKALUNDA, NEAR BOWEN.

Specimens of gypsum penetration-twin crystals have been received by the Geological Survey Office, Brisbane, from Eukalunda, near the Durham Mine, where they are stated to occur in a formation in granite close to sedimentary rocks.

Fig. 3.



GYPSUM PENETRATION-TWIN CRYSTALS.

The accompanying figure illustrates two of the twin crystals, the drawings being made to natural size.

TELLURIDES OF GOLD, SILVER, AND LEAD AT GYMPIE.

Two tellurides, Hessite and Altaite, occur in a number of places below the 600-feet level at the No. 2 South Great Eastern Mine, Gympie. The specimens here described were received some time ago, but have only recently been examined.

The Hessite is of a lead-gray colour; has a bright metallic lustre; fracture, varying from irregular to sub-conchoidal; hardness, about 2; and sectile. The percentage of silver in the mineral is 50.339, that of the gold being 5.049. Tellurium percentage undetermined; sulphur, absent; specific gravity, 8.50.

The Altaite is remarkable for its very distinct cubical cleavage; the colour is tin-white on a fresh facture, which rapidly tarnishes to a greenish-yellow bronze, this on exposure changing to pale yellow-bronze; hardness, 2½; sectile. The blowpipe and other reactions indicate the presence of the tellurium and lead, with traces of sulphur. The percentage of gold present is 0.09, that of silver being 0.70; specific gravity, 8.10.

The two minerals are in a matrix of quartz and calcite, and together constitute about 50 per cent. of the mass. Native gold and minute traces of a brownish mineral (probably siderite) are also present.

CALCITE CRYSTALS WITH PYRITES INCLUSION, AT GOLDEN GATE, CROYDON.

(PLATE 5.)

In the block shaft being sunk at Roger's Extended Mine, on the Golden Gate line of reef at Croydon, a quartz reef has changed into calcite, in the cavities of which calcite crystals have been formed.

Figure 2, Plate 5, shows the general appearance of the crystals as they appear in groups, with the lines of pyrites inclusions passing through them. Figure 1, on the same plate, illustrates the character of the twinning, the pyrites dust inclusions on the terminal faces, and the median line of microscopic crystals of pyrites traversing the group of calcite crystals at right angles with the principal axis.

Brisbane, 8th April, 1905.

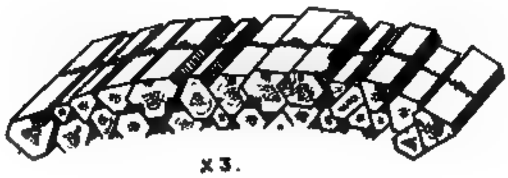
By Authority: George Arthur Vaughan, Government Printer, William street, Brisbane.

CALCITE

ROGER Nº 1 MINE GOLDEN GATE CROYDON

Showing the inclusions of particles of Pyrites
in a twinned group of Calcite crystals

Fig. 1



x 3.

Fig. 2

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